1961 NASA AUTHORIZATION

HEARINGS

BEFORE THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS AND SUBCOMMITTEES NOS. 1, 2, 3, AND 4 U.S. HOUSE OF REPRESENTATIVES

EIGHTY-SIXTH CONGRESS

SECOND SESSION

ON

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CONTENTS

Statement of—
Page
Abbott, Ira H., Director, Aeronautical and Space Research, National Aeronautics and Space Administration; accompanied by Maj. Gen. Don R. Ostrander, Director, Office of Launch Vehicle Programs; John W. Townsend, Col. D. H. Heaton, and Maj. Victor Hammond 27, 100
Barclay, Brig. Gen. John A., Commander, Army Ballistic Missile Agency, and Deputy Commanding General, Army Ordnance Missile Command, Redstone Arsenal, Ala.; accompanied by Maj. Leonard S. Frankenstein, Lt. Col. Robin Elliott, WAC; and Lt. Conrad C. Ege 90
Branch, Brig. Gen. Irving L., USAF, Chief, Aircraft Nuclear Propulsion Office, Assistant Director for Aircraft Reactors, Atomic Energy Commission; accompanied by Col. Jack L. Armstrong, Deputy Chief, Aircraft Nuclear Propulsion Office, and Lt. Col. Guveren M. Anderson 409
Dryden, Dr. Hugh L., Deputy Administrator, National Aeronautics and Space Administration 471
Finger, Harold B., Chief, Nuclear Propulsion, Office of Launch Vehicle Programs, National Aeronautics and Space Administration 336, 473
Godel, William H., Division of Projects and Planning, Advanced Research Projects Agency 461
Hammond, Maj. Victor W., USAF, Technical Assistant to the Assistant Director for Space Flight Operations, National Aeronautics and Space Administration, Headquarters 100
Hjornevik, Wesley, L. Deputy Director, Office of Business Administration, accompanied by Ralph E. Ulmer, Budget Officer, National Aeronautics and Space Administration 205
Horner Richard E., Associate Administrator, National Aeronautics and Space Administration 272, 311
Horner, Richard E., Associate Administrator, National Aeronautics and Space Administration; accompanied by Ralph E. Ulmer, Budget Officer; Robert Nunn, Associate General Counsel; and James Gleason, Asssistant Administrator for Congressional Relations 3
Hyatt, Abraham, Deputy Director, Launch Vehicle Programs, National Aeronautics and Space Administration 289
Luker, Comdr. Robert, Projects Officer, Advanced Research Projects Agency 467
Ostrander, Maj. Gen. Don R., Director, Office of Launch Vehicle Programs; accompanied by Col. D. H. Heaton, National Aeronautics and Space Administration 59
Siepert, Albert, Director, Office of Business Administration, National Aeronautics and Space Administration; accompanied by Wesley L. Hjornevik, Ralph E. Ulmer, Robert G. Nunn, Jr., and David Keyser 251
Silverstein, Dr. Abe; accompanied by Milton B. Ames, Jr., Wesley L. Hjornevik, Thomas E. Jenkins, Morton J. Stoller, and Charles J. Donlan 124
Ulmer, Ralph E., Budget Officer, National Aeronautics and Space Administration 205
Wyatt, D. D., Associate Director for Program Planning and Coordination, Office of Space Flight Programs, National Aeronautics and Space Administration 274, 381
Full committee hearings held on—
February 17, 1960 1
Subcommittee hearings held by—
Subcommittee No. 1—
February 18, 1960 27
February 19, 1960 57
February 22, 1960 89

Subcommittee hearings held by—Continued

Page

Subcommittee No. 2—
- February 18, 1960—Executive 123
- February 19, 1960—Executive 149

Subcommittee No. 3—
- February 18, 1960 205
- February 23, 1960—Executive 251

Subcommittee No. 4—
- February 18, 1960 .....
- February 22, 1960 271
- February 23, 1960 307
- February 24, 1960 345
- February 26, 1960 409
- February 26, 1960—Executive 467

1961 NASA AUTHORIZATION

WEDNESDAY, FEBRUARY 17, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D. C.

The committee met at 2:30 p.m., Hon. Overton Brooks (chairman) presiding.

The CHAIRMAN. The committee will come to order.

Before we get into the testimony this afternoon I want to say that when we agreed to divide the bill and turn it over to the subcommittees for more rapid handling, we were not quite finished with our full committee hearings on this posture program. As a result, we have several witnesses next week who are civilian witnesses and who are coming from a distance. Dr. Sheldon, our technical director, tells me that some of these men can't come, save on the dates indicated. Dr. George R. Arthur, president of the American Astronautical Society, Inc., of New York, can come on the 23d, but he can't come at another date within the near future.

We have Dr. Howard Stanley Seifert who is from Pasadena, Calif. He has quite a trip and he has set up his program to be here on the 23d. Likewise, Dr. H. Guyford Stever of Cambridge, Mass., has done that.

Here is Mr. Nelson B. Jackson, president of the National Rocket Club of Washington. We could, I imagine, set another date for him.

Then Prof. William H. Pickering, from California, plans to be here, too. He can only be here on Wednesday the 24th. Well, that would seem to me, the 24th, to be an easy problem. We can meet at 9:30 and hear Dr. Pickering before the subcommittees get started, without interfering with the work of the subcommittees.

From then on we want to give the subcommittees clearance to act. We are giving the subcommittees from Thursday to Thursday, a solid week, to do the work. Now, I mention this to you, because, if it wasn't for these men coming from such a distance—and they are distinguished scientists, too—if it wasn't for that fact, I would say postpone their appearance. But I think we would have to arrange to schedule them Tuesday and we can probably do that Tuesday morning. Then, to that extent only, will we interfere with the subcommittee hearings. Other than that, the subcommittees will have a full week. My thought is that they will report back Thursday, that is, tomorrow a week. Then, that will give us enough time to get the subcommittee reports together, take them up in the full committee the following Monday, and pass it out of the full committee to the House of Representatives. Then we will go for a rule before the Rules Committee. But even at that speed it will take around 2½, 3 weeks to get it upon the

floor, and that is about all the time that they can give us. I wanted to mention that to you.

(Aside from Mr. Moeller.)

The CHAIRMAN. That is up to the subcommittees. I don't see why they shouldn't. Many, many a year we have met on Washington's Birthday. That is nothing unusual. The House is in session on Washington's Birthday. It is up to the subcommittee chairmen. The only thing is, I want the subcommittees to have their work in by Thursday a week so that we can go ahead.

I think this is an extremely important hearing, because this will collate the work of the subcommittees on the bill itself and give you some general facts and figures covering the entire bill, which you on the subcommittees will fit to your particular work of the committee.

(The text of the bill follows:)

[H.R. 10246, 86th Cong., 2d sess.]

A BILL To authorize appropriations to the National Aeronautics and Space Administration for salaries and expenses, research and development, construction and equipment, and for other purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there are hereby authorized to be appropriated to the National Aeronautics and Space Administration for the fiscal year 1961 (a) such sums as may be required for "Salaries and expenses" and for "Research and development," and (b) the sum of $122,787,000 for "Construction and equipment," as follows:

(1) Langley Research Center, Hampton, Virginia: Hypersonic aerothermal dynamics facility and dynamics research laboratory, $11,957,000.

(2) Ames Research Center, Moffett Field, California: Centrifuge equipment, $980,000.

(3) Lewis Research Center, Cleveland, Ohio: Energy conversion laboratory and basic materials research laboratory, $9,100,000.

(4) Goddard Space Center, Greenbelt, Maryland: Payload testing facility; satellite systems, laboratory; and utility installations, $9,500,000.

(5) Pilotless Aircraft Station, Wallops Island, Virginia: Precision trajectory determination system; operations computing center; and equipment modernization, $4,000,000.

(6) Jet Propulsion Laboratory, Pasadena, California: Land acquisition; modernization of laboratory facilities; solid propellant facility; liquid propellent test cell; and antenna range, $5,000,000.

(7) NASA Huntsville Facility, Huntsville, Alabama: Saturn static test facility; central laboratory and office facility; dynamic test facility; pressure test cell; and additions to existing facilities for structures engineering, guidance and control, fabrication, checkout, and assembly, $26,750,000.

(8) Atlantic Missile Range, Cape Canaveral, Florida: Completion of the Saturn launching complex, escape mechanism, hydrogen system, new Saturn launching complex, staging building, and addition to the engineering and laboratory building, $27,750,000.

(9) Various locations: Tracking facilities, $27,750,000.

(c) Appropriations for "Research and development" may be used for any items of a capital nature (other than acquisition of land) which may be required for the performance of research and development contracts: *Provided*, That none of the funds appropriated for "Research and development" pursuant to this Act may be used for construction of any major facility, the estimated cost of which, including collateral equipment, exceeds $250,000, unless the Administrator or his designee notifies the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate of the nature, location, and estimated cost of such facility.

(d) Appropriations for "Research and development" may be used, in any amount not to exceed $20,000 for emergencies and extraordinary expenses upon the approval or authority of the Administrator and his determination shall be final and conclusive upon the accounting officers of the Government.

(e) When so specified in an Appropriation Act any amount appropriated for "Research and development" and for "Construction and equipment" may remain available without fiscal year limitation.

SEC. 2. Authorization is hereby granted whereby any of the amounts prescribed in subparagraphs (1), (2), (3), (4), (5), (6), (7), (8), or (9) of subsection 1(b) may, in the discretion of the Administrator of the National Aeronautics and Space Administration, be varied upward 5 per centum to meet unusual cost variations, but the total cost of all work authorized under such subparagraphs shall not exceed a total of $122,787,000.

SEC. 3. Any amount, not to exceed $5,000,000, of the funds appropriated for "Construction and equipment" pursuant to this Act, may be used to construct, expand, or modify laboratories and other installations, if found by the Administrator to be necessary because of changes in the national program of aeronautical and space activities or new scientific or engineering developments and if the Administrator determines that deferral until the next authorization Act would be inconsistent with the interest of the Nation in aeronautical and space activities, and in connection therewith to acquire, construct, convert, rehabilitate, or install permanent or temporary public works, including land acquisition, site preparation, appurtenances, utilities, and equipment: *Provided*, That upon reaching a final decision to implement, the Administrator or his designee shall notify the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate of the cost of such construction, expansion, or modification including those real estate actions pertaining thereto: *Provided further*, That no such funds shall be used for construction, expansion, or modification if authorization for such construction, expansion, or modification has been previously denied by the Congress; and additional appropriations are hereby authorized for purposes of this section in the amount of $5,000,000.

The CHAIRMAN. Mr. Horner, do you have a statement?

Mr. HORNER. I do not have a prepared statement this afternoon, but if it is—I am afraid it is going to inconvenience some of the members of the committee a little bit. I have some charts to talk to from here that I would like to use.

The CHAIRMAN. They wouldn't mind moving over here left of center.

Mr. FULTON. Mr. Chairman, as a matter of qualification, could I ask Mr. Horner to put in the record his title and the provision under which he is hired.

The CHAIRMAN. We think he is a very important man and, if you will give the reporter your exact title and the scope of your experience, we would appreciate it very much.

Mr. FULTON. The slot you are in and also what other slots there are of equal rank.

STATEMENT OF RICHARD E. HORNER, ASSOCIATE ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY RALPH E. ULMER, BUDGET OFFICER; ROBERT NUNN, ASSOCIATE GENERAL COUNSEL; AND JAMES GLEASON, ASSISTANT ADMINISTRATOR FOR CONGRESSIONAL RELATIONS

Mr. HORNER. Sir, I am employed with the National Aeronautics and Space Administration as the Associate Administrator, with the responsibilities of management of the operating program. Perhaps the closest analogy is one of the general manager in other Government programs. I am employed under the provision in the Space Act which permits the Administration to employ 10 people within the salary range of $19,000 to $21,000.

I am employed at the $21,000 level. Within the Administration I believe we have four other people employed at that level.

Mr. FULTON. Is your Associate Director title given to you by a regulation of the agency? It is not by statute?

Mr. HORNER. It is not by the statute. If I may correct you, sir, it is Associate Administrator.

Mr. FULTON. Yes.

Mr. HORNER. It is a title which I believe is given by the Administrator.

The CHAIRMAN. Mr. Fulton doesn't think you have any title and that is important, to have the proper title.

Mr. FULTON. I wanted it to be a statutory authorization, a position that will differentiate you, because of your responsibilities, from the nine other people in the same slot. I would, therefore, have it designated as either Program Director, Associate Administrator, or have a designation that would have him come in here with a responsibility directly to this committee as well as to the Administrator. You see, I want a much broader responsibility for him. We can then check with somebody on how the programs are going.

The CHAIRMAN. As we begin to read the bill for amendment you can offer your amendment then. I know you wouldn't want Mr. Horner to comment on that, himself.

Mr. FULTON. Could I ask what the Administrator and the Deputy Administrator get? Is it $22,500?

Mr. HORNER. Frankly, I don't know.

Mr. FULTON. Mr. Gleason, supply that for the record. Include the whole series, the first 2 plus the next 10.

Mr. NUNN. It is provided by statute. The Administrator's salary is $22,500, and the Deputy Administrator's salary is $21,500.

The CHAIRMAN. Mr. Gleason, would it be possible to give us later a list for the record of all of those employed under that special category from $18,000, I believe it is, up to $22,000?

Mr. GLEASON. Yes; we will be happy to do that.

The CHAIRMAN. Now, there is a rollcall.

Mr. FULTON. I can tell you what it is, it is the tax bill, withholding by the Federal Government of city wage taxes.

Mr. HINES. That is right, it is on the tax.

The CHAIRMAN. Is that what it is, a tax bill?

Mr. HINES. Yes.

The CHAIRMAN. We will go ahead until the second call of the roll and then we will have to recess for a few minutes so we can vote.

Mr. HORNER. All right, sir. May I proceed?

The CHAIRMAN. Yes; until the second call. You will hear the buzzer.

Mr. HORNER. Yes, sir.

Mr. Chairman, gentlemen of the committee, it is my purpose here this afternon to recapitulate the testimony that has been given by officials of the NASA for the past 3 weeks in terms of the fiscal implications of our budget authorization request. Dr. Glennan, Dr. Dryden, and myself, earlier in testimony, have explained to the committee our program objectives, our principles of management, administrative policies, and our long-range plan, together with the overall resources that are required to implement this program. I would like

to assure the committee that we are deeply conscious of our responsibilities in this new program which we are conducting without too much precedent; we are deeply conscious of our responsibilities to maximize the return per dollar for the expenditure of these public funds. We have also had numerous project officers treat individual segments of the program in some detail and with each element of this program there has been an estimate of the financial requirements.

I am afraid this may have left a rather fragmentary picture of our overall financial requirements. So today I would like to summarize these requirements and put them in the context of the overall program. I would like to use a few charts.

First, to draw a little bit of history, in the financial performance of the Administration, and show you what our resources were in fiscal year 1959, what they are in fiscal year 1960, and what we are requesting in fiscal year 1961 (fig. 1). I would point out that the sum that we

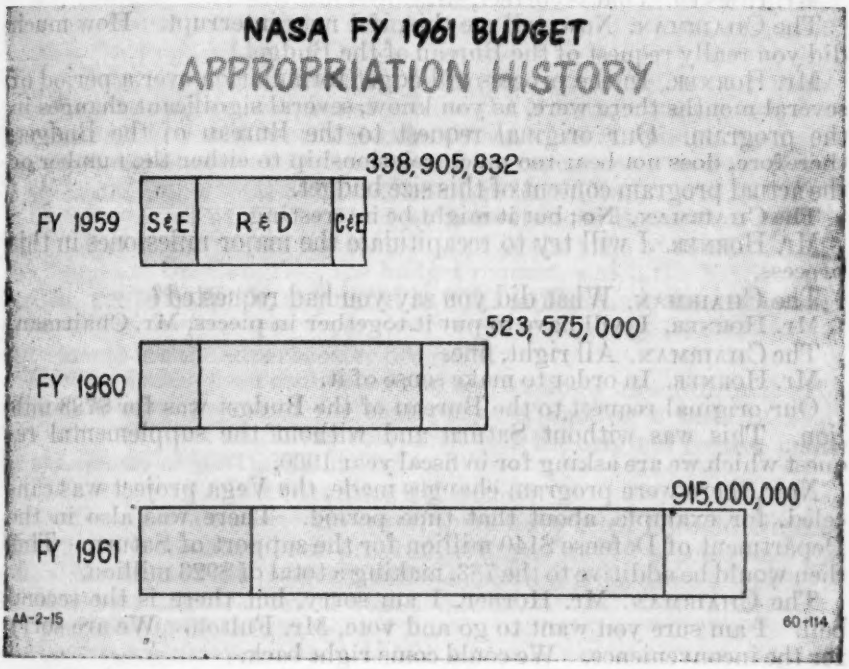

FIGURE 1

have here for fiscal year 1959 was made up of a combination of resources transferred from other Government agencies, together with those appropriated directly to the administration.

The CHAIRMAN. For the purpose of the record, that is $338 million, isn't it?

Mr. HORNER. $338,905,832.

Mr. FULTON. I ask unanimous consent to put his charts in at the respective places in the record.

The CHAIRMAN. If there is no objection, the charts will be put in at the proper place in the record.

Mr. HORNER. I will point out that the 1960 number is augmented for comparison purposes by the $23 million supplemental request which is currently before another committee of the Congress.

The CHAIRMAN. So that will give you for the 1960 fiscal year $523 million plus $23 million?

Mr. HORNER. No, sir. We have now appropriated for 1960 a total $500,575,000. I have already added the $23 million supplemental request to provide this number.

The CHAIRMAN. It gives you a total of $523 million.

Mr. HORNER. That is correct. My purpose in doing that was to provide an indication of the growth and rate of growth of the program. I would like to assure the committee that based on this start, the requested authorization for 1961 is, we feel, the minimum essential requirement to carry out the program.

The CHAIRMAN. That is $915 million?

Mr. HORNER. That is correct, sir.

The CHAIRMAN. Now, tell me this, if I may interrupt. How much did you really request of the Bureau of the Budget?

Mr. HORNER. In the process of budget formulation over a period of several months there were, as you know, several significant changes in the program. Our original request to the Bureau of the Budget, therefore, does not bear too much relationship to either the number or the actual program content of this size budget.

The CHAIRMAN. No; but it might be interesting.

Mr. HORNER. I will try to recapitulate the major milestones in this process.

The CHAIRMAN. What did you say you had requested?

Mr. HORNER. I will have to put it together in pieces, Mr. Chairman.

The CHAIRMAN. All right, fine.

Mr. HORNER. In order to make sense of it.

Our original request to the Bureau of the Budget was for $783 million. This was without Saturn and without the supplemental request which we are asking for in fiscal year 1960.

Now, there were program changes made, the Vega project was canceled, for example, about that time period. There was also in the Department of Defense $140 million for the support of Saturn. This then would be additive to the 783, making a total of $923 million.

The CHAIRMAN. Mr. Horner, I am sorry, but there is the second bell. I am sure you want to go and vote, Mr. Fulton. We are sorry for the inconvenience. We could come right back.

Mr. FULTON. Maybe we could have a Republican caucus and a Democratic caucus before we go over and vote.

The CHAIRMAN. I see what you mean. We will recess for 10 or 15 minutes.

(Whereupon, at 2:55 p.m., a recess was taken until 3:15 p.m.)

The CHAIRMAN. The committee will come to order. All the members will be back real soon. The voting in the House is about over.

Now, Mr. Horner, we were proceeding with you, sir.

Mr. HORNER. All right, sir.

To recapitulate this first chart for just a minute, Mr. Chairman, I was pointing out the rate of growth of the program in terms of the financial resources which have been made available to us and which we are requesting for the current year.

As you know, we request our authorization and appropriation in three different accounts, one for salaries and expenses, one for research and development, and one for construction and equipment.

I would like to look at those on a little larger scale.

The CHAIRMAN. Before you reach that, in 1961 you say you requested seven hundred some odd million, and you added $100 million for the——

Mr. HORNER. Yes, sir, Mr. Chairman, I apologize. I was going through that explanation when the committee adjourned. If I may, I will just go back and pick that up.

The CHAIRMAN. All right.

Mr. HORNER. Our original request was for $783 million. We at that time considered a $35 million supplemental request for fiscal year 1960. Within the Department of Defense there was an account of $140 million for the support of Saturn. When the responsibility for superbooster development was transferred to the NASA, it was agreed that the $140 million which at that time appeared in the budget proposal for the Department of Defense would be transferred to that of the NASA, making a total at that time of $923 million.

In the process of further budget formulations there were several program changes within the NASA, and at the time of submission of the budget to the Congress, the budget request, which the NASA submitted, you will recall, amounted to $802 million and about the same time we had instructions from the President to study further the requirements for the superbooster program.

That study has been completed and as you know an additional $113 million is now requested for that purpose, making a total of $915 million, which you might say compares with the original request made by the agency of $923 million.

The CHAIRMAN. Just $8 million difference?

Mr. HORNER. Yes, sir. However, there have been, I would emphasize again, there have been program changes in the process and the actual elements of the program differ somewhat from those at the time the original budget requested was submitted.

Does that complete it, sir?

The CHAIRMAN. Yes.

Mr. HORNER. The pie chart (fig. 2, p. 8) on your left shows the breakdown in the various accounts of the appropriation: "Research and development," $621,453,000; "Salaries and expenses," $170,760,000; "Construction and equipment," $122,787,000. I would like to discuss each of these in more detail. I think it is worth noting that the "Research and development" account which is the account from which all of our contract project activities is supported, is more than two-thirds of the entire budget.

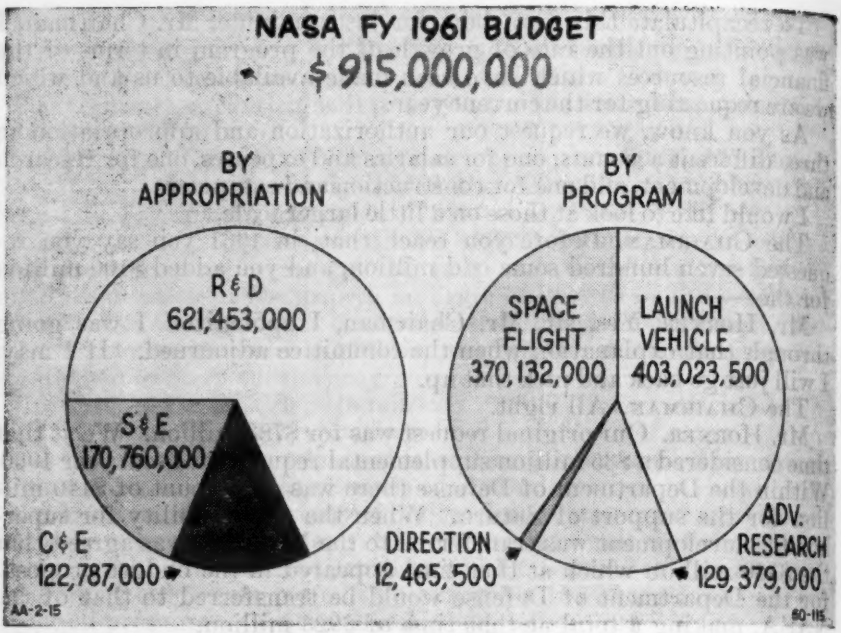

FIGURE 2

Before I turn to these individual accounts, however, I think it might be of interest to look at a different division, a functional division of the program support in terms of the way our organization is divided and the way the program is actually implemented. The first category is launch vehicle development at $403,023,500. The space flight category, which is actually the development of spacecraft for both exploration and application purposes requires $370,132,000, and the advanced research program which is the research that is actually carried out in our ground base facilities, and lays the foundation for the development program of the coming decade, accounts for $129,379,000. At about 1 percent of the total program cost we have an item for program direction which is the cost of our headquarters operation and the operation of certain liaison officers in various locations in the country.

It is significant to note, I think, that in the one area which we are acknowledged to be behind our international competition, that is our weight-lifting capability, we are spending the bulk of our resources to rectify that situation in the launch vehicle development.

Now to go to the individual accounts (fig. 3), I would like to talk first about the salaries and expenses. In this account we can identify the commitments on a geographical basis, actually, the support of the personnel we hire in the Administration and where they are located.

FIGURE 3.—*NASA fiscal year 1961 budget, salaries and expenses*

	Number of employees at end of year	Requested
NASA Headquarters, Washington, D.C.	683	$9,890,000
Langley Research Center, Virginia	3,220	29,295,000
Ames Research Center, California	1,440	15,244,000
Lewis Research Center, Ohio	2,736	25,724,000
Flight Research Center, California	416	3,679,000
Goddard Space Flight Center, Maryland	2,000	25,084,000
Wallops Station, Virginia	300	2,678,000
NASA Huntsville Facility, Alabama	5,500	58,313,000
Liaison, various locations	78	853,000
Total	16,373	170,760,000

In the headquarters in Washington we propose to have at the end of fiscal year 1961, 683 people in the headquarters at a cost in salaries and expenses of $9,890,000. This, as you see, is the bulk of the cost of this program direction item that I mentioned earlier.

Then, at our three research centers and the flight research center, which is an experimental effort, we have the salaries for the employees, for these staff sizes here [indicating], which are stable at these sizes, and have been for the past 3 years. At the Goodard Space Flight Center we have the new development center tailored to the requirement of spacecraft development, proposing staffing at the end of fiscal 1961 at 2,000 at a cost of $25 million. By far the largest element in this account is the support of the new Huntsville Center, 5,500 employees for a charge of $56 million. And, as I mentioned earlier, we have various liaison offices in the United States, a total of 78 employees.

The CHAIRMAN. When you come to that Huntsville facility, they testified that the Von Braun team was composed of 4,500 persons. You have 5,500. Why the difference of a thousand?

Mr. HORNER. The difference, sir, is that required to provide the administrative management and logistic support which has, in the past, been furnished by other elements of the Army outside of the Development Operations Division of which Dr. Von Braun was the director. In transferring the Von Braun group out of the Army Ballistic Missile Agency, we must recognize that that particular group constituted one of four divisions within the Army Ballistic Missile Agency.

Some elements of the management support for that group came from the headquarters of the Army Ballistic Missile Agency, from the headquarters of the Army Ordnance Missile Command, and we have reached agreements with the Army to select certain of those personnel to transfer into this organization. There will be some addition of people in order to make this an organization that can live by itself.

The CHAIRMAN. Mr. Fulton?

Mr. FULTON. Before you leave that point, I think it is a very worthwhile point. The question is on the transfer of the people of the Von Braun team from ABMA to NASA where you have adequate slots on civil service of a high enough rating and enough variable that you

can keep a lot of those high-ranking scientists and keep them at a level that you ought to have them. You see, is your slot structure correct? I understood that a lot of these people were higher than you had high-level slots for. There are more of them than you had high-level slots for.

Mr. HORNER. I will try to recapitulate that situation as it exists today, Mr. Fulton.

There are within the technicians and scientists of the Development Operations Division today, as the chairman mentioned, approximately 4,300 people. Of these, 19 now occupy what is known in the Department of Defense as supergrade positions. This is above the normal graded service level in the Civil Service structure. They are at the GS–16, 17, or 18 level or at a position salaried between $14,000 and $19,000, as provided for in Public Law 313.

In transferring to the NASA, it has been agreed that all of these positions except one for the incumbent Pershing project director, who will complete his assignment as a part of the Army, will be transferred to the NASA.

In addition to that we currently plan to provide to the new NASA Huntsville Center 20 of the excepted position allocations which we have under the Space Act of 1958.

From that basis you will see the——

Mr. FULTON. What salary range are they?

Mr. HORNER. Those are within the salary range of $14,000 to $19,000.

From that basis you will see that the status of some of the scientists at the new Huntsville Center will be markedly improved over their salary and grade structure status at the moment.

Now, it is true this is not the complete story. It should be noted that pending within the Department of Defense, at the time of the transfer, were requests from the Development Operations Division of ABMA for additional supergrade structure. The extent to which this request might have been allowed, we have no way of knowing—I don't think anybody does. But it does indicate an assessed requirement by the personnel within the division for additional high grade positions and it is accurate to say that their assessed requirement for additional high grade positions is not fully met by the allocation we have made of 20 additional positions, but the 20 additional positions does constitute all we have available for that purpose.

Mr. FULTON. That is what I am trying to get. What is the deficiency, so we might give you statutory authority to get more?

Mr. HORNER. We have not completed, yet, a study of the full deficiency. In terms of what had been requested, I have been told—only by word of mouth and I have not seen a formal request—that it amounts to something between 20 and 30 positions as a deficiency.

Mr. FULTON. With the chairman's permission can he put a statement in the record at this point?

The CHAIRMAN. Yes.

(The information requested is as follows:)

STATEMENT RELATING TO NASA REQUIREMENTS FOR EXCEPTED POSITIONS

With regard to our need for excepted positions, we have made a study of our program requirements and find that an additional 30 positions are needed. We have developed a legislative proposal and appropriate supporting material providing for an increase from 260 to 290 excepted positions.

This proposal also includes provision to increase from 10 to 13 the number of such positions which may be established within the salary range from $19,000 to $21,000.

These requirements have the approval of the Bureau of the Budget.

STATEMENT OF REQUIREMENTS FOR ADDITIONAL NASA EXCEPTED POSITIONS

This statement is in support of NASA's request for 30 additional excepted positions to cover expanding program requirements beyond those which can be encompassed within the existing 260 excepted positions now authorized under section 203(b) of the Space Act of 1958.

At the present time, NASA has established 218 of the 260 positions authorized. It has filled 208 of these with 10 commitments to individuals who have not yet reported for duty. The distribution of these by salary rate and by location is shown in the attached listing. Practically all positions at the $16,000 level and above are those of chiefs of major divisions in the research and space flight centers, and of chiefs of key professional or technical programs in the headquarters.

The criteria used in selecting individuals for excepted positions and in determining salary rates are based on the scope and complexity of the work itself and specific consideration of the individual's reputation and achievements and his promise of further contribution in the proposed position. The Administrator considers for approval under this special authority only those individuals whose qualifications have been screened and endorsed by an executive salary committee composed of the top program leadership in NASA headquarters. The Deputy Administrator, Dr. Hugh L. Dryden, is the chairman of this committee.

Of the 218 established positions, 82 are used in the headquarters. These positions are filled with individuals who head up professional and technical functions for the total space program, except for nine positions which are allocated to executive type personnel heading key functions in the business management area.

A total of 136 jobs are currently allocated and used by NASA's various field centers. At the principal research centers the average ratio of excepted positions to the total research scientists and engineers is approximately 3.8 percent.

Compared with the present NASA ratio of 3.8 percent, the Huntsville Von Braun group has Army allocated positions equal to 1.8 percent. The addition of 20 excepted positions which NASA can make available within its present limit of 260 positions will bring this percentage to 2.8 percent. The request before the committee for an additional 30 NASA excepted positions is based upon programed requirements for 16 more excepted positions at Huntsville. This will give the new NASA facility 54 positions above GS–15 salary levels. The ratio of such positions to the total professional staff would then be 4 percent.

The request for 30 positions includes 4 additional scientific and technical jobs to be located in the Langley Research Center, 1; the Lewis Research Center, 2; and the Goddard Space Flight Center, 1. When these are added to the existing allocations for these centers, the overall percentage of scientific and engineering personnel holding excepted positions exclusive of Huntsville will be 3.9 percent.

Within the additional 30 positions, it is proposed to allocate 8 additional headquarters positions in the $14,000 to $19,000 range. These are all positions requiring exceptional scientific and technical training. The particular positions in this request are as follows:

(1) Staff scientist (program evaluation), Office of Program Planning and Evaluation;

(2) Staff scientist, nuclear propulsion research programs, Office of Advanced Research.

(3) Chief, scout class vehicles, Office of Launch Vehicle Programs;

(4) Chief, advanced technology programs, Office of Launch Vehicle Programs;

(5) Staff scientist, guidance systems;

(6) Staff scientist, lunar sciences, Office of Space Flight Programs;

(7) Chief, flight systems development (lunar and planetary programs), Office of Space Flight Programs; and

(8) Chief of advanced development, space flight operations, Office of Space Flight Programs.

Finally, within the 30 additional requested positions NASA is asking that 3 of these be authorized in the pay range $19,000 to $21,000. These would be programed as follows: (1) The Director of the NASA Huntsville facility; (2)

the Director of the Office of Launch Vehicle Programs (this position to be held as a contingency for a civilian appointee in case the post should become vacated by the present incumbent, an Air Force major general); and (3) one position, as yet undesignated, to be held by the Administrator in reserve for future program developments.

The CHAIRMAN. When you make the transfer and you allot these 20 or 30 positions, does that amount to a pay raise for these people?

Mr. HORNER. Yes, sir; in each case.

The CHAIRMAN. And how much?

Mr. HORNER. It will vary depending upon the individual, his qualifications, and the position he happens to occupy in accordance with the grade structure that is standardized throughout the administration.

Mr. ULMER. One to five thousand.

The CHAIRMAN. What will be the average increase?

Mr. HORNER. I would say the average will be, at the low side of that extreme, because generally, of course, the individuals are being paid now commensurate with their position responsibilities under the prevailing Government pay scale.

Mr. FULTON. Of the 10 slots that were made available under the Space Act of the 85th Congress, are any of those unfilled?

Mr. HORNER. There is one vacant at the present time; yes, sir.

Mr. FULTON. At that level, certainly, there must be a few coming in from the Huntsville installation that should fit into that group. Shouldn't that group be larger?

Mr. HORNER. Our present practice, Mr. Fulton, is to have in that category at the field centers only one position, and that is the director of the center.

Mr. FULTON. So that would be Von Braun in this case?

Mr. HORNER. Yes, sir.

Mr. FULTON. But none of his top-team men is going to be up at this level?

Mr. HORNER. Above $19,000 and up to $21,000?

Mr. FULTON. Between $19,000 and $21,000.

Mr. HORNER. If they were, it would not be consistent with the rest of our organization.

The CHAIRMAN. Well, let me ask you this: Has the Bureau of the Budget approved a pay increase?

Mr. HORNER. We have statutory authority, sir.

The CHAIRMAN. You what?

Mr. HORNER. We have statutory authority.

The CHAIRMAN. I know. But do they have a request for the necessary appropriations?

Mr. HORNER. Our appropriation provides for the——

The CHAIRMAN. For the increase?

Mr. HORNER. For the increase, yes.

The CHAIRMAN. In the light of the Presidential policy of holding the line on salaries, I am wondering what will be the position on this?

Mr. HORNER. Well, we do have in our budget authorization request adequate money in the salaries and expense account to provide for paying these particular positions. Will you correct me on that?

Mr. ULMER. Yes, sir; we do have for the current 260 authorized ceiling.

The CHAIRMAN. You have legislative authority to go ahead and do it without Congress?

Mr. HORNER. Yes, sir.

The CHAIRMAN. So you really don't need any help from this committee?

Mr. FULTON. Yes; and providing these extra slots for these high level people that he is going to put the statement in on. I agree with you on the $14,000 to $19,000 class, but the thing I am speaking of are these supergrades, whether these scientists will be satisfied because now they will be working for a civilian agency and we are in competition with the outside civilian people who are also working on Government contracts.

Mr. HORNER. Mr. Fulton, we are only now in the process of designating people that will be transferred, of alining people with their positions, and we are in the midst, right now, of this kind of a study. We will be happy to provide the results of this to the committee when it is available.

It is a very complex matter in which we must go into the details of each individual position and each individual and it is going to take a matter of a few weeks to get this straightened out.

The CHAIRMAN. Are you telling the committee, now, that you are not going to need any more money to do this?

Mr. HORNER. We are not going to need any more money, Mr. Chairman, to carry out the grade structure for which we have authorization in the Space Act of 1958. That is correct.

The CHAIRMAN. But to create the additional slots you will need more money?

Mr. HORNER. We not only need more money, we will need more position authority.

The CHAIRMAN. More authority too?

Mr. HORNER. Yes, sir.

The CHAIRMAN. And all of them will be a grade level with a minimum of $18,000.

Mr. HORNER. The present structure provides for two different types of excepted positions, one within a range of $14,000 to $19,000, and then the restricted number of 10 that vary from $19,000 to $21,000.

The CHAIRMAN. But that is where you need your authority.

Mr. HORNER. Sir, I am not prepared to say at this time the extent to which we need that authority.

Mr. FULTON. If we are going to try to work on this bill, the question is, could you give us a pretty firm estimate that we could then get it in our authorizing bill? I think that a provision of this kind, which would provide for salary increases in a separate piece of legislation, might have pretty rough going.

The CHAIRMAN. There is no question in my mind that it would have rough going, certainly.

Mr. FULTON. So you will have to get an estimate up here pretty quickly.

Mr. HORNER. I think we can provide such an estimate in a short time period.

Mr. FULTON. That is all.

The CHAIRMAN. Mr. Hechler.

Mr. HECHLER. Is it all right to ask another question on Huntsville at this point or do you have an order of proceeding here? Is it all right to ask one?

The CHAIRMAN. Surely. Go ahead and ask him.

Mr. HECHLER. I am still a little puzzled about that 1,000 increase in personnel over what it used to be under the Army. This amounts to an increase of nearly one out of five employees.

I am a little puzzled as to why you need all that overhead in addition to the people that are actually going to do the work. I heard your explanation, but I am just puzzled why the excessive amount of a thousand additional.

Mr. HORNER. Mr. Hechler, may I emphasize that that is not a net increase of employment? At least 815 of these are people who are now currently employed in different organizations in the Army who will be transferred with this group in order to make this group a complete one.

Mr. HECHLER. Let me clarify that by asking whether it took exactly the same number of people when the entire organization was under the Army for such overhead purposes?

Mr. HORNER. Of at least the same order of magnitude. It is very difficult to say that it took the same number since both military and civilian staff were used by the Army in supporting the Development Operations Division. But one would suspect that it takes somewhat more to run two organizations independently than it takes to run one. That is literally what we are doing here.

It is true that the total responsibilities of each organization individually are reduced from what they were when they were joined together. I think we are probably going to end up with new employees of a few hundred, in that area.

Mr. HECHLER. I think it would be useful for subcommittee purposes at least to have some type of a more specific breakdown on that.

Mr. HORNER. We can break down the numbers in detail. I don't have them with me here today. I will be glad to supply them for the subcommittee's consideration.

Mr. HECHLER. Yes, I think that is probably a subcommittee matter.

Mr. HORNER. For the construction and equipment programs (fig. 4), this is another account which we can break down by geographical location, since it provides new facilities which are necessary for carrying out the program.

FIGURE 4.—*National Aeronautics and Space Administration, fiscal year 1961 budget—Construction and equipment programs*

Aeronautical and space research facilities:	
Langley Research Center, Va	$11,957,000
Ames Research Center, Calif	980,000
Lewis Research Center, Ohio	9,100,000
Space flight development and operations facilities:	
Goddard Space Flight Center, Md	9,500,000
Wallops Station, Va	4,000,000
Jet Propulsion Laboratory, Calif	5,000,000
NASA Huntsville Facility, Ala	26,750,000
Atlantic Missile Range, Fla	27,750,000
Tracking and data acquisition	27,750,000
Total	122,787,000

The first category, aeronautical and space research facilities, is simply the modernization of the facility complex at the research centers to orient them toward the space program, as opposed to the aeronautical program that was carried out there in the past years.

In space flight development and operations facilities, these are facilities that are necessary for the space flight development centers and for the operation of space vehicles.

You will notice in the account, $91½ million of additional facilities at the new Goddard Space Flight Center, and $4 million for improving the capability at Wallops Island, where a large fraction of our sounding rocket program, and scout operational program is to be carried out. New facilities for the jet propulsion laboratory are provided for its orientation in support of the deep space craft development responsibility.

By far the biggest account, again, of course, is for the NASA Huntsville facility and the Atlantic Missile Range, both of which are largely in support of the Saturn development program and, as you can see, these sizes of facilities are quite expensive.

The last line item, of course, is the tracking and data acquisition requirements at various locations around the world.

The CHAIRMAN. Do you include in that Atlantic Missile Range the operation at Cape Canaveral?

Mr. HORNER. That is almost entirely an investment at Cape Canaveral.

The CHAIRMAN. It is?

Mr. HORNER. Yes, sir.

The CHAIRMAN. So that is not the downrange cost then? It is Cape Canaveral mostly?

Mr. HORNER. We do not have any downrange costs at the Atlantic Missile Range. We are using entirely the facilities of the Department of Defense with the exception of special facilities at the newer stations that we are providing in support of Project Mercury.

The CHAIRMAN. Now, you just said that the Atlantic Missile Range in Florida was almost entirely a part of the Mercury program?

Mr. HORNER. Saturn program.

The CHAIRMAN. Saturn program.

Mr. HORNER. The big bulk of this number is for the construction of a Saturn launch facility.

The CHAIRMAN. Isn't the Atlantic Missile Range used for all types of tests?

Mr. HORNER. Yes, sir; it is. It just happens that most of the facilities we need for other projects are in position there through prior year investment and through investment by the Department of Defense. There are some dollars in here for construction of facilities in support of other programs. I just mentioned that the biggest part of this was for Saturn.

Mr. FULTON. Mr. Chairman, would you yield?

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. Before you leave this particular chart on construction, there have been some stories going around—I have read several of them—that we are going to take $1,500 million for either the changing of highway bridges or tunnels or changing highways so that these large space missiles and vehicles could be carted around. One story

had it that it was going to cost the State of Pennsylvania $25 million to change tunnels and bridges. There is nothing really to that, is there? There is no study, plan, or program on it? Actually, I haven't heard any presentation on it, but I have seen some very remarkable stories.

Mr. HORNER. In the context of our present program, Mr. Fulton, that story is completely false. We have no element of our program which requires overland transportation which will in turn require modification of standard clearances.

Mr. FULTON. So there is really no dispute between the Federal Government and any State or local municipality on constructing such things to handle missiles?

Mr. HORNER. Not in—excuse me, sir, I cannot speak for the missile program, but as far as the space program is concerned this is true.

Mr. FULTON. On the space program I mean.

Mr. HORNER. To the best of my knowledge, we have the largest devices that are currently under development in the space program. Now, it is true that the first and second stages of the Saturn are too large for overland transportation. We will in each case plan to transport those by water to the launch site.

We turn now to the research and development programs—figure 5. The first item, research at advanced research centers of $61 million; this is for support of research projects at the four centers which I noted on the previous chart: Lewis Laboratory, the Ames Laboratory, the Langley Laboratory, and the Flight Research Center.

FIGURE 5.—*NASA fiscal year 1961 budget—Research and development programs*

Research at advanced research centers	$61,345,000
Space science and exploration	94,700,000
Satellite applications	26,300,000
Manned space flight	107,750,000
Vehicle system development	215,008,000
Space propulsion technology	83,800,000
Tracking and data acquisition	32,550,000
Total	621,453,000

The next two line items, space science and exploration and satellite applications, is the money required for the support of development of spacecraft. This is the complete cost proposed for the development of spacecraft with the exception of that for manned space flight which is a project unto itself on the next line item and was discussed for you yesterday by Mr. Low. Here again you can see a breakout of the relative size of expenditures that are proposed for vehicle system development and space-propulsion technology, which is, of course, our effort to overtake the international competitor and provide for ourselves the necessary delivery capability. The tracking and data acquisition then is the operation cost of the worldwide data gathering networks.

Mr. FULTON. On the space propulsion technology, how much is in that for boron research and development? If you don't have it now, put it in later.

Mr. HORNER. A relatively small amount, Mr. Fulton. I will have to provide that for the record.

(The information requested is as follows:)

Under space propulsion technology, for basic combustion work pertaining to rockets, approximately $10,000 is allocated to boron fuel research in fiscal year 1961.

The CHAIRMAN. Mr. Moeller.

Mr. MOELLER. In connection with the tracking and data acquisition program, is there some operation in conjunction with the Navy, for example, in this, that NASA doesn't have to have entirely its own separate devices?

Mr. HORNER. We are very carefully coordinated with the entire Department of Defense and using largely Department of Defense facilities.

The CHAIRMAN. This is NASA's share in this?

Mr. HORNER. Yes, sir; and to a large extent this is the cost of actual operations that required, in addition to the defense operation in support of our programs. In other words, the way this works out in most cases is that these are expenditures that are necessary solely because of our program. We frequently find that we can get a free ride on the Department of Defense, where they are providing the capability for their own program which is also adequate to our needs.

The CHAIRMAN. I see.

Mr. HORNER. But there are many elements of our program that are unique. For example, the entire Mercury structure, the Mercury instrumentation and tracking structure is almost unique to the Mercury program in about two-thirds of the circumference of the world. So those programs we have to pay total costs on.

Mr. FULTON. I have one more question: There has been comment of a new program of cooperation with Canada and also with Australia, would those international cooperation programs be under this particular budget? How much are they?

Mr. HORNER. I would like to provide the financial details for each one of those programs for the committee if I may. They are different with different nations, depending upon our agreements with the different nations, which in turn depend upon the relative capabilities of the country we are speaking of.

For example, perhaps the most common arrangement is for the foreign country to provide the spacecraft and we are providing the launch vehicle. We both benefit from the data that is gained.

In looking at it in one respect, this is a net advantage to the free world's program, since we in the United States get the data cheaper by not having to develop the spacecraft.

Mr. FULTON. For example, I don't want it to go on, at Jodrell Bank, University of Manchester, with Dr. Lovell—do you have in there funds, for example, for getting some of the time——

Mr. HORNER. There is money in this tracking and data account for paying salaries at Jodrell Bank during those time periods when they are working on our space experiments. This is done under contract with Dr. Lovell.

Mr. FULTON. If you could put in the record the part of the budget that is cooperation with the free nations in outer space work, I would like it. Not for now, but I would like it, with the chairman's permission.

Mr. HORNER. All right, sir.

(The information requested is as follows:)

The fiscal year 1961 estimate includes funds for the operation of non-NASA stations as follows:

Jodrell Bank, England	$300,000
Fort Churchill, Canada	700,000
All other	400,000
Total	1,400,000

Mr. MCDONOUGH. On the tracking and data acquisition, that includes all the tracking stations around the world?

Mr. HORNER. Yes, sir.

Mr. MCDONOUGH. Is that duplicated by the Defense Department or do they use the same facilities?

Mr. HORNER. We use the defense facilities where they exist. However, I would point out that the defense facilities generally have not been required all the way around the world, therefore, for those missions where we have worldwide requirements, we have had to supplement the defense facilities.

For example, most of the defense facilities have been built in support of missile programs. Missile programs have been generally designed to some nominal range like 5,000 or 6,000 or 8,000 miles. This means that they have only required range instrumentation for that length of the circumference of the globe. In Project Mercury we are using the stations that are part of the Atlantic Missile Range, the Pacific Missile Range and the White Sands Range, but we are also having to supplement those in areas where no stations existed.

Also in the deep space net there was no worldwide capability. There was at Goldstone, in the California desert, a single dish which was placed there originally by the Army. This was under the management of the jet propulsion laboratory. When the laboratory was transferred—the contract responsibility for the laboratory was transferred to NASA, we inherited that big dish station. We are having, however, to create additional stations as was pointed out the other day, one in Australia and one in South Africa, to give us global coverage.

Mr. MCDONOUGH. The point I am making is, couldn't we have one tracking and data acquisition facility around the world to be used for civilian experiments as well as defense purposes, instead of having two?

Mr. HORNER. Yes, sir; we can and we do, as far as organizational jurisdiction is concerned. We have to have different kinds of networks for different kinds of functions, however. A network which is optimized for taking data from vehicles which are in deep space at the moon and beyond, for example, is not suitable for a low-flying satellite. So we have to have different kinds of networks, but as far

as organizational jurisdictions are concerned, we can and we do have melding together of the networks.

Mr. McDONOUGH. The same personnel can operate it?

Mr. HORNER. Yes, sir.

The CHAIRMAN. You use the dark fence, don't you?

Mr. HORNER. The dark fence is for a very specific purpose. We could use information from the dark fence but it is a responsibility of the Department of Defense and is not directly useful to our program.

It is primarily designed to detect noncooperative satellites and we hope that all of our satellites are going to be cooperative.

Mr. McDONOUGH. Now, on the manned-space flight item there, what percentage of that total is for Mercury?

Mr. HORNER. It is practically all for Mercury. There I think, is $2 million in there for studies for manned-space flight beyond Project Mercury, but other than that, it is all for the support of Mercury.

The CHAIRMAN. Any further questions?

Mr. FULTON. You are already talking about going beyond Project Mercury, the Moon or Mars?

Mr. HORNER. That is what the study is for, Mr. Fulton, to determine what is the next logical step beyond Mercury.

Mr. FULTON. Have any steps been taken at all toward the joint use with the Soviets of these facilities that we have set up?

Mr. HORNER. You may be aware that we have proposed through the United Nations to the Soviet Union the use of our Mercury network for any manned space flight program that they might have.

Mr. FULTON. What has been the response to it? That is what I am talking about.

Mr. HORNER. To my knowledge, we have had no response.

Mr. FULTON. Could you put that in the record, the offer, something about it, and what its present status is?

(The information requested is as follows:)

During the meeting of the American Rocket Society in Washington, D.C., in mid-November 1959, NASA initiated an informal discussion with Soviet scientists to explore their attitude toward cooperation in space research. The Soviet scientists, L. I. Sedov, A. A. Blagonravov, and V. Krassovsky, indicated they were favorably disposed but that cooperation must proceed step by step. The only step they were willing to specify was mutual support of the U.N. Space Conference proposed by their delegate to the United Nations.

The Administrator of NASA, in a speech made on December 7, 1959, at the Institute of World Affairs, Pasadena, Calif., offered to utilize the services of the Project Mercury tracking network to track a Soviet manned satellite, in the event such a project is carried out, and, of course, if the Russians provide the necessary information on such a satellite. This offer was transmitted formally to the Soviet Academy through the U.S. National Academy of Sciences. This offer is a specific application of IGY and post-IGY practice with regard to the tracking of all artificial satellites and the exchange of the resulting data.

In January 1960, the above offer was also transmitted directly to Sedov at the Soviet Academy of Sciences. Additional possibilities of cooperation, already disseminated to the international community (at the COSPAR meeting in Nice in early January) were described. Thus, it was stated that the telemetry codes and calibrations used in connection with Explorer VII would soon be available and might be obtained for reduction of data possibly recorded by Soviet scientists. Copies of such recordings were requested in writing.

In addition, it was stated that NASA is prepared to collaborate in similar measurements from U.S.S.R. spacecraft.

Finally, detailed information as might be required to utilize NASA's Project Echo for passive communications experiments or studies of atmospheric drag was provided to the Soviet Academy, as had already been done more widely in the scientific community.

No response or acknowledgment has yet been received to these proposals or suggestions.

The CHAIRMAN. Will the gentleman yield?

We offered to help them, didn't we, on this ballistic missile program that they had over there in the Pacific? We offered to send facilities over there.

Mr. HORNER. To my knowledge we in the NASA did not. If there was such an offer from this Nation, I would suspect it would be from the Department of Defense.

The CHAIRMAN. Any further questions?

Mr. MCDONOUGH. Mr. Chairman, while we are on that, the report was that they hit the target within a mile and a half.

The CHAIRMAN. Less than a mile.

Mr. MCDONOUGH. Less than a mile and a half of the target. I understand the target was an enormous area. What was the area of the target? Do you know?

Mr. HORNER. I do not know, sir.

Mr. MCDONOUGH. The fact that they hit it within a mile and a half of the target doesn't mean that they came very close to the bull's-eye, does it?

Mr. HORNER. I am sorry. I feel a little bit uneasy talking about this in open session. If the chairman would care to, I think it would be more appropriate for closed session.

Mr. MCDONOUGH. OK.

The CHAIRMAN. Well, the gentleman feels it is classified?

Mr. MCDONOUGH. I will withdraw the question.

The CHAIRMAN. All right.

Further questions?

Does that conclude——

Mr. HORNER. That concludes the discussion of the program. There is one other matter which I would like to illustrate for the committee. There has been concern, I know, in the past, relative to the portion of the program carried out in our own facilities as compared with that portion of the effort which we contract with American industry (figure 6). I think the committee is properly concerned that we optimize the use of the vast and diversified field of American industry.

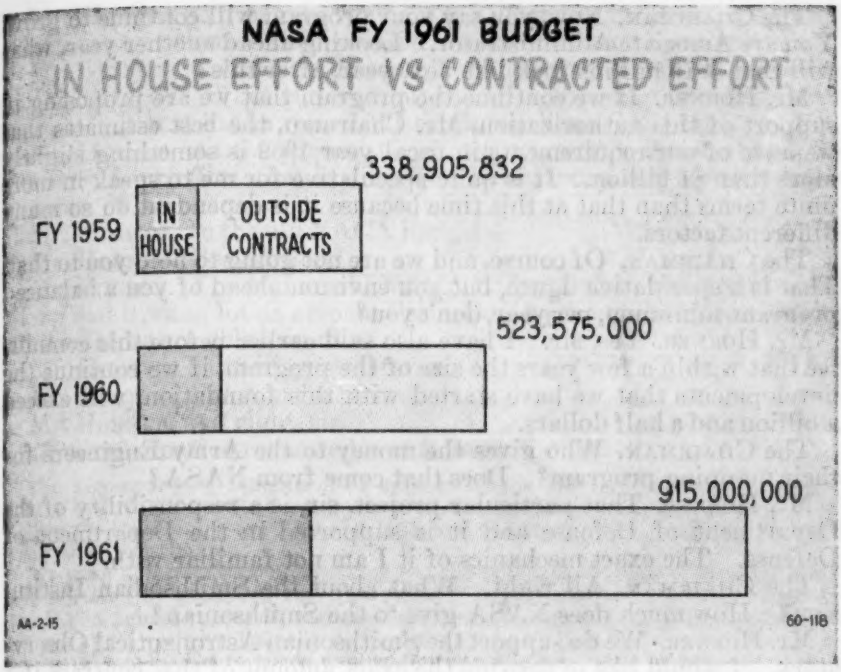

FIGURE 6

I have had this chart made just to illustrate the problem as it currently exists and to make a very brief statement of what our policy is in the matter, and what we intend to do about it (fig. 6).

As you can see, our ratio of outside contracts to inhouse expenditures in fiscal year 1959 was about 3 to 1. This actually has gone up in fiscal year 1960. This is a reflection of the fact that our program has increased in size at a more rapid rate than our inhouse capability, our organization has increased in size.

In fiscal year 1961 there will be a slight reversal of this trend, primarily because of the method of formulation of our organization and, of course, in this year this reflects the amalgamation of the Huntsville facility with our organization where we take on in one action 5,500 new employees.

But even in this circumstance, we will still have 72 percent of our work in out-of-house contracting and as we have mentioned before in front of this committee, we expect that our program will continue to grow. We intend to hold the size of our organization and our in-house capability stable and in the process of doing this a larger fraction of our program actually will depend upon contracts with industry, with nonprofit institutions and with American universities.

The CHAIRMAN. Now, you say your program will continue to grow. You are Associate Administrator. Looking ahead another year, what will that $915 million look like next year, after this?

Mr. HORNER. If we continue the program that we are proposing in support of this authorization, Mr. Chairman, the best estimates that we have of our requirements in fiscal year 1962 is something slightly more than $1 billion. It is quite speculative for me to speak in more finite terms than that at this time because it is dependent on so many different factors.

The CHAIRMAN. Of course, and we are not going to hold you to that. That is a speculative figure, but you envision ahead of you a balanced program, minimum, per year, don't you?

Mr. HORNER. Yes, sir. I have also said earlier before this committee that within a few years the size of the program, if we continue the developments that we have started with this foundation, will exceed a billion and a half dollars.

The CHAIRMAN. Who gives the money to the Army Engineers for their mapping program? Does that come from NASA?

Mr. HORNER. That particular project, sir, is a responsibility of the Department of Defense and it is supported in the Department of Defense. The exact mechanics of it I am not familiar with.

The CHAIRMAN. All right. What about the Smithsonian Institution? How much does NASA give to the Smithsonian?

Mr. HORNER. We do support the Smithsonian Astronautical Observatory. I would like to provide the exact amount of that contract if I may for the committee.

The CHAIRMAN. You also have projects with the Smithsonian and they have some very capable scientists there too.

Mr. HORNER. Yes, sir; they do indeed. We have had a very excellent relationship with their scientists. They are doing very useful work for us.

The CHAIRMAN. I happen to know they are a little bit concerned for fear that the program might be reduced with the Smithsonian.

Do you know whether there is any proposal at this time to reduce the program or the use of the Smithsonian scientists and facilities as you have in the past?

Mr. HORNER. We have a very real requirement for their services in the future space program.

The CHAIRMAN. Don't you get excellent results from the Smithsonian scientists?

Mr. HORNER. They have been very competent in performing the functions that we have asked them to do.

The CHAIRMAN. Mr. Fulton.

Mr. FULTON. The question comes up on the divisions of programs. I am one of those that is deeply interested in oceanography, having been a Navy Reserve officer.

What is the amount in the current fiscal year and the next fiscal year, 1961, for oceanography? How big a program is it? What kind are they? What should we be doing in it?

Mr. HORNER. Sir, I am sorry. I don't know. That, of course, is not a part of our program.

Mr. MCDONOUGH. Astronautics.

Mr. FULTON. Well, this is science. This is on the science space——

Mr. HORNER. All of our work, Mr. Fulton, is, in accordance with our statutory responsibility, pointed toward aeronautics and space.

Mr. FULTON. Could you divide off the programs between aeronautics and space? What is the amount you are spending on aeronautics as such? Put it in the record. I think we should have that.

Mr. HORNER. At the present time, at the research centers, about 25 percent of our effort, that is this effort here [indicating], goes for the support of aeronautics.

Mr. FULTON. In the old NACA budget——

Mr. HORNER. Beg pardon?

Mr. FULTON. You had an old NACA budget before the NASA came along and it was a lot on aeronautics. Could you correlate that budget with what we are doing now?

Mr. HORNER. I can in general terms.

Mr. FULTON. Put it in the record.

Mr. HORNER. All right, sir.

(The information requested is as follows:)

The accompanying tabulation of appropriations and expenditures is for the NACA and NASA for the fiscal years 1955 through 1961 inclusive. Expenditures shown for the fiscal years 1960 and 1961, and the appropriations shown for fiscal year 1961 are estimates.

We have no direct way of breaking out the portions of these figures that were appropriated or expended for "the peaceful exploration of space." Generally, the NACA figures represent aeronautical research rather than space exploration, although it is estimated that in fiscal years 1958 and 1959 the research conducted by NACA applicable to space exploration varied from 30 to 50 percent. NASA figures generally represent space exploration, except that in 1960 and 1961, between $30 million and $35 million will be used to continue the advanced aeronautical research.

Appropriation title	Appropriations	Expenditures [1]
NACA		
1955:		
Salaries and expenses	[2] $52,240,000	$73,796,890
Construction and equipment	4,620,000	
1956:		
Salaries and expenses	60,135,000	71,257,328
Construction and equipment	12,565,000	
1957:		
Salaries and expenses	62,676,500	75,946,632
Construction and equipment	14,000,000	
1958:		
Salaries and expenses	76,076,209	89,193,258
Construction and equipment	41,200,000	
1959:		
Salaries and expenses	78,100,000	103,491,016
Construction and equipment	23,000,000	
NASA		
1959:		
Salaries and expenses	8,186,300	42,000,000
Research and development	[3] 204,619,532	
Construction and equipment	25,000,000	
1960:		
Salaries and expenses	91,400,000	[5] 360,000,000
Research and development	[4] 335,350,000	
Construction and equipment	[6] 73,825,000	
1961:		
Salaries and expenses	[5] 170,760,000	[5] 640,000,000
Research and development	[5] 621,453,000	
Construction and equipment	[5] 122,787,000	

[1] Includes expenditures on prior-year construction programs.
[2] Includes $1,000,000 transferred from fiscal year 1954 "Salaries and expenses" appropriation.
[3] Includes $154,619,532 transferred (72 Stat. 433) from the Department of Defense.
[4] Pending supplemental for $12,200,000 not included.
[5] Estimated.
[6] Pending supplemental for $10,800,000 not included.

Mr. FULTON. That is all, Mr. Chairman.

Mr. BASS. Mr. Chairman.

The CHAIRMAN. Mr. Bass.

Mr. BASS. If the Congress appropriates for fiscal 1961 the $915 million you request, will that be about what you will spend?

Mr. HORNER. We have a growing program, Mr. Bass, and, of course, expenditures always lag obligations by several months or a few years, depending upon the type of expenditures.

Some of our obligations, such as those for salaries and expenses we will spend out largely in the first year, the year that they are obligated. For the research and development program, this $621 million, however, only a relatively small percentage of it will be spent in the first year.

I believe we have provided to the committee our estimate of expenditures for the current fiscal year and the way those expenditures will be influenced by this obligation.

As a general matter, they will not spend this much. It is in the neighborhood of $360 million.

Mr. ULMER. $360 million for this year.

Mr. BASS. $360 million for what year?

Mr. ULMER For expenditures for the current fiscal year 1960.

Mr. BASS. What will your estimated expenditures be for 1961?

Mr. ULMER. Perhaps $600 to $650.

Mr. BASS. Not much more?

Mr. ULMER. Not too much more. Many of these contracts are 2-, 3-, and 4-year contracts, particularly the capital investment items and the expenditures may be spread over 4, 5, and 6 years.

Mr. BASS. I understand.

Mr. DADDARIO. Mr. Chairman.

The CHAIRMAN. Mr. Daddario.

Mr. DADDARIO. What are your maximum salary limits in the NASA budget?

Mr. HORNER. The maximum salary limits——

Mr. DADDARIO. Talking about individual salaries?

Mr. HORNER. In NASA there are 10 positions at the level of $19,000 to $21,000, 250 positions at the level of $14,000 to $19,000 and on the balance of our positions from $13,900 down, we have no statutory restriction.

Mr. DADDARIO. Is there any recommendation being made that these limits might be raised to attract special type of personnel?

Mr. HORNER. I pointed out to an earlier question that in—in response to an earlier question, that we are currently conducting a study of our personnel requirements, specifically, of course, in connection with the transfer of the Development Operations Division of the ABMA to NASA and we will provide to the committee our requirements within the next few weeks.

Mr. DADDARIO. Are there any people within the ABMA who are getting more than those limitations now?

Mr. HORNER. No, sir; the people at ABMA were employed under the civil service structure. They did have 16 positions which were above the $13,900 level, which is the top level of a GS–15, which ranged in salary structure from $14,000 to $19,000.

Mr. DADDARIO. Is there any indication that you might lose some of these people within the period of the transfer?

Mr. HORNER. We have no such indication; no, sir.

The CHAIRMAN. Any further questions? If not, I think that pretty well covers the whole bill. I have a lot of notes on it, but I think we have covered everything very well.

Now, we want to thank you very much for coming here, Mr. Horner, and helping us. Tomorrow morning we are going to have General Medaris and another witness, and then tomorrow afternoon——

Mr. DUCANDER. The subcommittees will meet.

The CHAIRMAN. The subcommittees will meet tomorrow afternoon. I am glad to announce that. Won't you have a seat?

Mr. HORNER. Thank you, sir.

The CHAIRMAN. If you are in a rush, we will excuse you, but I had one little matter to mention to the committee.

It seems as though we have got a lot of spare time on our hands, at least some people seem to think so, because they gave me this note here. The meeting of the organizing members of the Institute of Space Law of the International Astronautical Federation is going to occur in Paris March 21 and March 22, and approximately on the same date in Geneva there will be a meeting on the law of the high seas.

Mr. DUCANDER. I don't know what organization it is.

The CHAIRMAN. That is at Geneva, certainly.

Mr. BASS. Send Captain Fulton.

Mr. FULTON. No, Captain Ducander.

Off the record.

(Discussion off the record.)

The CHAIRMAN. The gentleman is out of order.

Approximately at the same dates in Geneva, the law of the high seas, an attempt to reach international agreement on extension of 3-mile limit to the 12-mile limit, and maybe beyond there, and other important matters.

Now, I mention that to the members of the committee. I don't see any chance for anybody on the committee to get off, unless they can do it between dark and daylight, because we have a heavy load. We are going to take up right after this bill, the Presidential proposals for revision of the Space Act. However, I have been asked to mention that to the members of the committee. If anybody feels optimistic to the point that he feels he can get away from the Congress and attend those meetings, why let the Chair know about it. I feel that while these gatherings abroad are important, it is also extremely important that we be here at our post of duty in the committee and on the floor of the House.

Now, I have done my duty when I mentioned that.

If anybody feels interested, let me know in the next few weeks, anyway.

If there is no further business, we will adjourn until tomorrow morning at 10 o'clock.

(Whereupon, at 4:05 p.m., the committee was adjourned, to reconvene at 10 a.m., Thursday, February 18, 1960.)

1961 NASA AUTHORIZATION

THURSDAY, FEBRUARY 18, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE No. 1,
Washington, D.C.

The subcommittee met at 2:15 p.m., Hon. George P. Miller (chairman) presiding.

Mr. MILLER. The committee will be in order. This is Subcommittee No. 1 of the Committee on Science and Astronautics, to which is referred the construction and equipment phase of the NASA budget.

Without further ado, we will hear from Mr. Ira H. Abbott, Director of advanced research program, NASA.

STATEMENT OF IRA H. ABBOTT, DIRECTOR, AERONAUTICAL AND SPACE RESEARCH, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY MAJ. GEN. DON R. OSTRANDER, DIRECTOR, OFFICE OF LAUNCH VEHICLE PROGRAMS; COL. D. H. HEATON; JOHN W. TOWNSEND; AND MAJ. VICTOR HAMMOND

Mr. ABBOTT. Thank you, Mr. Chairman. We appreciate this opportunity to present to you the NASA 1961 program for construction and equipment.

This program is presented in detail in the 1961 estimates of appropriations booklet on pages 300 to 427 with a summary and index given on pages 307 and 308.

The total amount requested for new construction and equipment is $122,787,000 of which $20,037,000 is to be used for essential new research facilities at the Langley, Ames, and Lewis Research Centers.

You will recall that these research centers were acquired from the former National Advisory Committee for Aeronautics. The new construction now being requested at these centers is necessary to provide research facilities with capabilities beyond any now existing to keep pace with the advancing technology and with the changing character of the research from predominantly aeronautical to space problems.

The amount requested represents about 5 percent of the original investment in the research centers.

Facilities for support of space flight development and operations are requested in the amount of $102,750,000. Of this amount, $9,500,000 is for the Goddard Space Flight Center at Beltsville, Md., to provide facilities that will be needed for the preparation, testing, and integration of scientific payloads for satellites and other space vehicles. At Wallops Island, Va., $4 million is requested to extend and modernize instrumentation and equipment at this launching site.

Modernization and replacement of obsolescent facilities at the Jet Propulsion Laboratory, Pasadena, Calif., will require $5 million. As you are aware, this laboratory is a Government-owned installation operated under contract with NASA by the California Institute of Technology.

We are requesting $26,750,000 for new facilities at the NASA Huntsville facility in Alabama. Most of these new facilities are required to support the Saturn project which is too large to be fully supported by existing facilities. A small amount of this request for Huntsville is associated with the transfer of this organization from the Army to NASA.

Most of the $27,750,000 requested for the Atlantic Missile Range, Cape Canaveral, Fla., is to provide facilities necessary to permit the launching of Saturn vehicles. As you know, the established practice at the Atlantic Missile Range is for the using agency, in this case NASA, to fund the special facilities needed for use of the range.

We are also requesting $27,750,000 for tracking facilities in various locations to improve the minitrack net, the deep space net, and to complete construction and instrumentation of the Mercury net.

I have with me Gen. Don. R. Ostrander, Director of Launch Vehicle Programs, Mr. John W. Townsend, Col. D. H. Heaton, and Maj. Victor Hammond.

We shall be pleased to discuss with you any or all of the items in this program in whatever detail you may wish.

Mr. MILLER. Mr. Osmers.

Mr. OSMERS. I would like to say to Mr. Abbott that I have not yet had an opportunity to visit any of the locations where the construction provided for in the bill is to take place.

I would make one exception to that. I have visited Cape Canaveral several times, but not in connection with the work of NASA.

If it could be done, very briefly, Mr. Abbott, and with the chairman's approval, I wonder if you would just give us a brief rundown by location of what we have there now and how this will be augmented in general terms.

Mr. MILLER. I think that would be a good idea. I have been at a number of these installations but for the sake of the record too, Sir, I think if you could tell us, start out with a little something about Langley, Ames, and Lewis, tell us about their missions, and what you accomplish at each one. It would be helpful for the record.

Mr. ABBOTT. Yes, sir. I would be happy to.

Suppose I cover the research centers and pass the problem to my colleagues for the other locations.

The first three places, Langley, Ames, and Lewis, were acquired from the National Advisory Committee for Aeronautics and represent three of the four research centers obtained from that agency; the other one being the Flight Research Center at Edwards, Calif., at which we are not requesting any construction and equipment this year.

Of these four——

Mr. MILLER. I may say for the sake of my colleague, if you look at page 310, I think you will find a map of Langley, and as we discuss it, he can tell us what they want.

Mr. ABBOTT. That map on 310 is a map of an extremely small area.

Mr. MILLER. It doesn't show all of the areas. This will show some of the things.

Mr. ABBOTT. Yes, this particular map covers only a little more than one block of an extensive area.

Mr. MILLER. I have walked around it, I know.

Mr. ABBOTT. I certainly hope Mr. Osmers will also have an opportunity to visit these stations and we will certainly do everything that is possible to make such visits convenient and pleasant to him.

We invite you to attend any or all of them.

Mr. OSMERS. I shall do so.

Mr. ABBOTT. Langley is the oldest of the research centers. It was started by the National Advisory Committee for Aeronautics about the end of World War I. The center is located on the Langley Air Force Base near Hampton, Va., and has a total complement of roughly 3,000 people.

The mission of the center in the days of the NACA was aeronautical research. Like all the research centers, this mission is being gradually changed to include space research, research on space problems. In fact, most of the activity at the research centers now is on scientific problems relating to space technology.

Mr. OSMERS. Are there any Air Force activities conducted there at all at Langley.

Mr. ABBOTT. Yes. Langley Air Force Base is a very active Air Force base. It is the headquarters for the Tactical Air Command, for instance. We occupy a portion of the base under an agreement with the Air Force and have done so since the start of the establishment down there.

The Air Force and the NACA went in at the same time near the end of World War I.

Mr. MILLER. You are the tenants of the Air Force on the base, is that correct?

Mr. ABBOTT. This is largely correct. We do have——

Mr. MILLER. In this case, you are the tenants of the Air Force. This is just for the information of my colleagues, if they haven't seen it. For instance, the NASA at Moffet Field is on a Navy field.

Mr. ABBOTT. Yes.

Mr. MILLER. You have your Ames Laboratory there. There you are the tenants of the Navy?

Mr. ABBOTT. Yes.

Mr. MILLER. You are on this field and the Air Force or Navy exercises no control or administration over the laboratory. I assume that it furnishes certain services, fire protection and guard services and that sort of thing, security services that are common to the field. Within the laboratories themselves, even though they happen to be on a military locality, you are there as tenants and you control your own facilities.

Mr. ABBOTT. That is correct. I would like to add to what you have said, that the relationships between ourselves and the Air Force in the case of Langley and the Navy in the case of Moffet Field and also between ourselves and the Air Force at Edwards Air Force Base in California, where the Flight Research Center is located, has always

been excellent. I cannot recall a single case of friction in all the years that we have been joint occupants of these installations.

Mr. CHENOWETH. Who is commanding Langley now?

Mr. ABBOTT. I am sorry. I can't tell you. You mean the Air Force?

Mr. CHENOWETH. The headquarters.

General OSTRANDER. General Everest.

Mr. ABBOTT. As the chairman has said, our operations are primarily independent of the military occupants of the installation. The military furnishes the general guard duty.

We are, however, responsible for detailed security arrangements in our own area. At Langley we get water supplied by the Air Force as part of the regular Air Force system. Fire protection is provided on a cooperative basis whereby the Air Force and ourselves contribute to the costs of the firefighting apparatus and the management of it on a basis which is sort of prorated with respect to the relative amounts of installation.

The Air Force serves very much, as far as we are concerned, in the same way as a city government serves an industrial establishment located in a city. It provides essentially the same services to us.

Mr. CHENOWETH. Are you expanding your facilities at Langley all the time?

Mr. ABBOTT. The facilities at Langley have been expanded a great deal over the years.

Mr. CHENOWETH. I was there about 6 years ago and, as I recall, you didn't take too much space at that time.

Mr. ABBOTT. I think there has been no increase in area since that time. There has been some additional building construction. We do not at this time visualize any further increase in space at that location.

The mission of Langley is research in the general fields of aerodynamics but more especially these days in the areas of structures and of environmental problems relating to materials and structures of the vehicles of the future, both aeronautical and space vehicles.

The mission of the Ames Research Center, which is about half the size of Langley, is aerodynamic research. They concentrate at Ames on very high speed aerodynamic research, on stability control and handling problems of both aeronautical and space vehicles.

At the Lewis Research Center, which is located on land which we own at Cleveland, Ohio, adjacent to the Cleveland Airport, the mission is research on propulsion and power generation. We do have a fairly clear-cut distinction between the missions of these three research centers, although there is some planned overlap between the missions of Langley and Ames Research Centers.

Mr. OSMERS. Mr. Chairman, I have one other question that seems pertinent.

While you have been speaking, Mr. Abbott, I have been going through the booklet here which gives the details of the improvements and the equipment that is to be installed in these various places.

Am I correct in assuming that many of the machines, many of the facilities, and much of the test equipment here has never been built before? It does not now exist? It will be built especially for NASA for use at these locations?

Mr. ABBOTT. This is exactly correct. The typical case is that this equipment is built for the first time by NACA or now by NASA. We have pioneered in the research areas in extending the capabilities of the laboratory equipment that is available—typically in the old days wind tunnels—to higher speeds and higher temperatures and larger sizes that were needed to get the data that are required. In doing this we have continually been forced to push forward into new engineering problems which have not previously been encountered.

Mr. OSMERS. This leads inevitably, of course, to the question of how do you determine the cost of a piece of equipment that has never been built before. I realize there must be an element of projection in it. It says specialized instruments, $35,000. I am sure that because of the description, "specialized instruments," that they are instruments you hope to develop. How do you come up with a figure, not for that particular item, but for any of them?

Mr. ABBOTT. In general, the first thing to determine is the possibility of constructing the equipment at all. There are, of course, many types of research equipment which we would like to have which is simply beyond our capabilities, or anybody's capabilities, to design and construct at any given time.

We are continually in our laboratories pushing forward into this frontier by small-scale experiments, theoretical calculations, and this sort of thing. If it begins to look as though something is becoming possible, we conduct small-scale experiment on pilot models to determine whether our concept is really within the realm of possibility or not.

We also have at our research centers very small but very experienced engineering groups who work on this sort of thing all the time. Our research people and these small engineering groups then get together, break down the concept of what is wanted into the various pieces and methods of construction that would be used to get it, and then our engineering people make estimates on these.

I can only say that the accuracy of these estimates depends mostly upon the experience of these people in doing this many times before, and the net result has been extraordinarily good, I believe, in the past. We are very proud of our record in this respect, of always producing for the money that is available, a complete, usable piece of equipment.

I will say that the final end product has not always been exactly what we said it would be at the time we made the request, but it has always been very close to that.

Mr. MILLER. On page 314 of the book, speaking of Langley, you start out with a helium heating system and pebble heater, $434,000. You break that down into the heating system and the pebble heater, ceramics. You haven't been using anything along this line very long; have you?

Mr. ABBOTT. We have had some experience with helium systems. There is one small helium system in operation at Langley, a small wind tunnel, and one which is——

Mr. MILLER. I think you have one at Ames.

Mr. ABBOTT. Approaching completion or completed now at the Ames Laboratory.

Mr. MILLER. I think I saw it when I was out there.

Mr. ABBOTT. We have also been using these pebble bed heaters extensively. In fact, we pioneered in this work.

Mr. MILLER. If I am not mistaken, just for the sake of my colleagues' guidance, you have a number of 8-inch guns all welded together that you use to get very high pressure——

Mr. ABBOTT. We have used that technique.

Mr. MILLER. And you release this hot helium. This is heated to give a greater pressure to get through this tunnel so that you can drive it through there for a short time at a much greater velocity than you could possibly do with pumps, isn't that right?

Mr. ABBOTT. That is correct, sir.

Mr. MILLER. You have to get this thing up to sometimes many machs and there is a limit when using ordinary pumps, rotary air pumps, to get compression; isn't that correct?

Mr. ABBOTT. Yes. The helium or air has to be compressed, but it also has to be heated. It has to be heated for several reasons. Heating the gas increases the speed of sound in the gas itself. Consequently, it will flow at a higher rate of speed for a given ratio to the speed of sound.

Heating the gas is also needed in some cases for environmental testing where you actually need to impose the heat on the model. Heating the gas also is necessary because as the gas expands in flowing through the apparatus it is cooled and air would actually liquefy before it went to the speeds which we are trying to reach today, unless it was heated very highly.

Mr. MILLER. Down at Langley don't you have really washed air, cleaned air under high compression?

Mr. ABBOTT. Yes, sir.

I believe your are referring to the gas supply in the gasdynamics laboratory which would be used with this first piece of equipment that you mentioned. That air supply is stored at 1,800 pounds per square inch which is a rather high pressure. For this particular facility, we will boost that to 15,000 pounds per square inch, which is an extremely high pressure.

Returning to Mr. Osmers' question, I think the breakdown of costs by which these estimates are made, this was mentioned by the chairman with reference to pages 314 and 315.

Here is a new piece of equipment and nothing like it has been built before. We do not have at this time a detailed design of this equipment, and we will not start a detailed design until after this request is approved by the Congress. However, for more than 2 years now we have been working on approximate design of this piece of equipment with a very small group, but a very skilled group.

The result is that you will notice that the total sum of nearly $8 million is broken down into a great many elements of which the helium heating system for $311,000 is one, pebble heater and ceramics for $323,000 is another.

I think on each of these items we have a very good idea that this is just about the costs for which this particular piece of equipment can be obtained. In many cases, already at this time, our design people have entered into discussions with industry with regard to the possibilities of building the particular pieces of equipment and to get from them as well as from ourselves estimates as to the cost.

These estimates from industry are not binding estimates at this time.

Mr. OSMERS. Did I understand you correctly to say that for the most part these figures had been reviewed with industry, to check them out as to the cost?

Mr. ABBOTT. I don't think I would be that positive about it, sir, but I would say that in any cases where there were serious doubts in our mind, we would discuss these items with people in industry to find out whether these were things that really could be built and about how much it would cost.

Mr. MILLER. That is the second group, the $1,236,000. Those are pretty standard. You know pretty well what those are.

Mr. ABBOTT. In heaters and ceramics, yes, we have a number of them now.

Mr. MILLER. I mean the electrical equipment and power systems.

Mr. ABBOTT. These are very standard items.

Mr. MILLER. Those have been pretty well checked out and this is a pretty firm estimate that you have.

Mr. ABBOTT. Yes, sir.

Mr. MILLER. The $434,000—no one can definitely tell us too much about that because it is pioneering and we have to accept that.

Mr. ABBOTT. The $434,000, we would have the best information on that ourselves. On electrical equipment and power systems, these are more or less standard items and on which there is good costing procedures.

As far as equipment foundations, building and utility revisions are concerned, these are more or less standard items on which past experience can be used. Things like settling chambers represent heavy steel construction. Again these are items that can be estimated fairly well from the nature of the construction, the type of steel and the overall weight.

Mr. MILLER. They are items peculiar to NASA or peculiar to investigational work of this nature rather than standard items?

Mr. ABBOTT. Yes, sir. These are not standard items, but they are items that can be built by standard methods of steel fabrication.

Mr. MILLER. The pressure, vacuum, helium and air piping, on page 315, and the cooling system, the air, helium, and vacuum storage, those, of course, are the ones that we pretty well have to estimate.

Mr. ABBOTT. These vary. Pressure and vacuum systems are things that can be estimated extremely well from other experience, both our own and experience of people such as the oil industry who use large vessels of this sort.

Even these new pieces of equipment do break down into items on which there is a lot of industrial experience on which we can rely.

Mr. MILLER. So then this total of $7,957,000 as one of the first items at Langley—do you have any question about that?

Mr. OSMERS. The question I have is not concerning the equipment at Langley specifically, Mr. Chairman. This equipment and the work provided for under this appropriation would be, I assume, done to a large degree by private contractors?

Mr. ABBOTT. Yes, sir.

Mr. OSMERS. In the cases where it is not practical or possible to give exact designs and so on, I assume that the contracts there would have

to be of a negotiated basis, is that correct? Or how would you go about that?

Mr. ABBOTT. This varies. We try to use competitive bids, wherever possible, and this is possible most of the time. In addition to our small engineering units, which can do preliminary design, we hire on contract engineering and architectural services from industry to complete designs for us and to provide detailed designs where this is appropriate.

In other cases, it is possible to enter into contracts on—what is the word——

Mr. OSMERS. Cost-plus?

Mr. ABBOTT. No, a performance basis, with somebody who does both the detail design and construction of the item from the preliminary design work. But wherever possible, and it is possible most of the time, we go into competitive bidding. Where this is not possible, we use what is called competitive negotiations.

Mr. OSMERS. One other question, Mr. Chairman, which does not have to do with Langley specifically.

There has been a great deal of continuing comment and criticism about the Nation's space program and whether it is behind where it should be and so on.

Since NASA is a very new agency, relatively, in the Government, could you just tell us in a few words how, at the top of the agency, do you pull together your need for facilities and your program and projects so that the part that we are discussing here today, the construction and equipment portion of your appropriation, how that is determined to be sufficient to complement the whole figure that is being proposed?

Mr. ABBOTT. Yes, sir. As you are undoubtedly aware, the budgetary process takes just about 1 year. We are now working on the 1962 budget.

The general guidelines are issued by the Administrator for the preparation of a new budget, giving in broad general rules the general nature of the program which should be undertaken for the coming year.

Mr. OSMERS. In dollars or in terms of accomplishment?

Mr. ABBOTT. I have never seen any specific dollars attached. It is mostly in terms of accomplishment, where this is possible. There are some cases where a level of effort has to be set because in research, for instance, one almost has to set a level of effort of activity.

These general guidelines are interpreted by the directors of the main line offices, of which there are two here today, General Ostrander and myself, to their people, and preliminary estimates are obtained from the field stations.

These estimates are discussed, both with the field stations and between ourselves, and with the Administrator, and his immediate assistants. This process gradually leads to something like a budget. At this point the Administrator last year, and I have every reason to believe he will do the same this year, appointed a committee to advise him on this budget. It was composed of people throughout the organization with expert knowledge in various fields to examine the whole budget. In addition to the examination given by the line people, and to research for areas of overlap, holes where things were

not covered that needed to be done to carry out the general program and this sort of thing.

Finally, this all comes together in a budget for his approval.

In the case of research equipment, the primary responsibility for saying what new equipment will be needed to meet the problems which we see we are going to have to face in the coming years rests with the research people.

Mr. OSMERS. Mr. Chairman, just one final question.

I notice that on page 315 the total estimated completion time of the nearly $8 million in construction and equipment there is estimated at 36 months.

In view of the generally held need for speed in advancing this program, is that in your judgment the shortest time that that program could be completed?

Mr. ABBOTT. Yes, sir. In fact, I think most people would say this is a very optimistic estimate. However, we expect to meet it.

One must remember that this is a brandnew piece of equipment which goes well beyond the present technology in many respects. This means that great difficulties will be encountered in the detailed design and fabrication of some of these parts. It also has in it long leadtime items, such as some of the electrical equipment where the leadtime is much in excess of a year, as a rule.

Mr. MILLER. The contractors can't furnish them to you under that time?

Mr. ABBOTT. No, sir. Before they can start, we have to determine in detail what is wanted and then this long leadtime equipment has to be finally installed in the project. This represents, I think, a very good estimate as to the time it will require to do this on an urgent basis.

Mr. MILLER. Then if there is no objection, we will approve that $7,957,000.

Mr. OSMERS. No objection.

Mr. MILLER. Will you go to the next item which is also there at Langley, the dynamics research laboratory. This is also a new piece of equipment that is designed to do a lot of experimental work?

Mr. ABBOTT. Yes, sir. The purpose of this equipment is to provide us facilities for studying the very critical problems of vibration, orientation, and dynamics of space vehicles. It will permit us to study both separately and in combination the effects of noise, vibration, acceleration, heat, vacuum, and this sort of thing on pieces of equipment which are not necessarily small but can also be rather large, approaching, if not being, full size for space vehicles that we foresee for the near future.

Mr. MILLER. This is where you try to put them through the run that they will get in space?

Mr. ABBOTT. Undoubtedly this equipment will be used to some extent for that purpose, but the primary purpose of the equipment is to do research on these problems so that the final equipment will have fewer problems of this sort after it is built.

The present dynamic equipment at Langley is about 20 years old now. It was designed for dynamic problems on airplanes, including such things as wing flutter, propeller work and this sort of thing. It is completely inadequate for the type of work that we are doing now.

Mr. MILLER. When you get into mach speeds, it is a little different than when you talked about 200 or 300 miles an hour.

Mr. ABBOTT. Yes, sir. The primary purpose of this equipment is to study the problems that will be encountered in space itself. The most essential features of the equipment are the two very large vacuum chambers; one a 60-foot sphere and another one a cylinder 60 feet high in which the equipment can be placed, both the test equipment and the items to be tested.

Mr. OSMERS. You will attempt to simulate conditions as they will be found in space?

Mr. ABBOTT. As well as we can do so on the ground. We feel problems of this type are growing in importance all the time.

Mr. MILLER. Incidentally, Mr. Ducander, feel free to come in. Do you have anything on the previous item.

Mr. DUCANDER. No, sir.

There is $519,000 for a new building?

Mr. ABBOTT. That is correct.

Mr. DUCANDER. There is presently a laboratory there. This will be modernization of the building?

Mr. ABBOTT. No; this will be a new building.

Mr. MILLER. If you look at the chart, I think you can see it.

Mr. ABBOTT. I can see your problem and this bothered me a great deal too in setting up the budget. We have a laboratory at Langley. We are not anticipating any increase of manpower at this time. This raises very serious questions as to why we should be building new buildings as such.

The situation at Langley is that we are very badly overcrowded in many respects. The Mercury project is down there, and the total amount of manpower at the laboratory has been increased as a result of this; that is, we have accommodated the Mercury group there. Also the existing dynamics research laboratory does not have any office space. It is just an open building which has now been converted for use to other purposes, and is really not used as a dynamics research laboratory anymore because it has become completely outdated.

Mr. DUCANDER. There is no other space in any of the research centers that could accommodate this new equipment?

Mr. ABBOTT. No, sir. We have examined that in detail on these projects and requests for new buildings have been reduced greatly.

Mr. MILLER. That takes care of the $11,957,000 for Langley, and without objection it will be approved.

The next item is at the Ames Research Laboratory, page 333. It is $980,000. Page 323 gives you the breakdown. This is a computer. A computer is one of the essentials in the $390,000 that they need out there very badly.

Mr. ABBOTT. Yes; they do. This centrifuge equipment that we have out there is an absolutely minimum equipment which was put together with scrounged surplus electrical drive equipment. We use the computer equipment which is already at the laboratory for other purposes and which, of course, cannot be used for other purposes when it is being used for this work. What we have here is a request for $980,000 to fix this centrifuge up in a manner—bring it up to a minimum standard of usefulness. I don't mean to imply it is not useful at the moment, because it is, but we are running on a shoestring.

Mr. OSMERS. Mr. Chairman, the statement that Mr. Abbott just made about bringing it up to a minimum standard might be subject to a bit of explanation. Is it possible or desirable to bring it up to a little bit above the minimum standard at this time? That has been bothering a lot of people in the country—the fact that we have been hovering at the minimum standard.

Mr. ABBOTT. This is something which I have been struggling with my conscience about for some time now with regard to this equipment. I believe this is the right course of action, sir. This whole question of centrifuge equipment in this country is a rather broad one.

As I think you know, there is a large centrifuge up at Johnsville which is a very fine piece of equipment for the purpose for which it is built and I might mention it is a very expensive piece of equipment.

It is not completely suitable for the type of work which we wish to do, which is different from the mission for which that centrifuge was constructed.

There has also been some consideration of other large centrifuges by either the military services or the NASA. I think there is some real uncertainty at the moment as to what type of centrifuge equipment should be constructed and where it should be built.

We have a minimum useful facility now at the Ames Laboratory. By putting approximately another million dollars into it, which will bring the total cost of the equipment to approximately $2 million, I am confident myself that in the next few years we can take the cream off the research problems for this type of a centrifuge and can do it before we could get a more elaborate piece of equipment built because such a piece of equipment would cost somewhere in the neighborhood of $10 to $20 million. It would require a design and construction time so long that I feel that we can get most of the cream off the research problems by the time we could get such a piece of equipment.

Now, if the research results obtained from this piece of equipment indicate that more elaborate equipment is needed in the future, why then I believe that is the time to go after the more expensive piece of equipment.

I do not believe that we either should spend such a large amount of money right now or that we should wait while it is being spent in order to get the essential research information we need quickly.

This is why I recommend going ahead on this basis. We can do a great deal of work on this piece of equipment.

Mr. MILLER. Without objection, we will approve the $980,000 at Ames and go on to the Lewis Center.

The first item is on page 328.

Mr. ABBOTT. The energy conversion laboratory. We are running into very real research problems in connection with the broad term "energy conversion." What we are thinking of here is the multitude of problems which have to do with converting energy from one form to another.

Applicationwise, we are thinking primarily of such things as powerplants for space vehicles. We need an integrated laboratory where this work can be done, including studies of such things as conversion of radiant energy to other forms, including electrical energy, the conversion of heat to mechanical and electrical energy, and to radiant energy; and, in particular, to study certain problems relating to the many chemical and mechanical conversion systems.

You will notice such items as a liquid metal pump facility, a liquid metal facility and this sort of thing in order to study the problems that are associated with boilers, pumps, turbines, and condensers, using the types of fluids that will have to be used in these space powerplants, which, in general, will not be steam as is customary here on earth.

In many cases these fluids may be liquid metals with all the special problems associated with them. We think this is a very important item.

Mr. MILLER. With the exception of the building and site preparation, you are again pioneering in the field, aren't you, by $3,850,000?

Mr. ABBOTT. We are; yes, sir.

Again the building is necessary because there are no suitable quarters for setting up this equipment at the Lewis Laboratory or, for that matter, at our other laboratories.

Much of the equipment at the Lewis Laboratory was centered originally around test cells and this sort of thing in connection with aeronautical engines. This room is now being used in connection with certain test setups for study of the new problems.

Mr. MILLER. How big is this building going to be? A 2-story building?

Mr. ABBOTT. Two-story and basement. It will be approximately 200 feet by 50 feet.

Mr. MILLER. Do you have any questions?

Mr. OSMERS. No. Again, Mr. Chairman, I remark this is a program, and I can understand why it would take time—it will take over 2 years, 27 months, and I realize even that may be an optimistic estimate.

I believe it is worth noting in the record that when you go into programs, such as energy conversion, that are largely new fields, it does take time to develop the facilities to test the equipment and to find out the answers to important questions.

Mr. ABBOTT. Yes, sir; it does.

Mr. MILLER. Well, without objection we will approve the $5,050,000.

The next one is the basic research laboratory. This is more building.

Mr. ABBOTT. This is the basic materials research laboratory, which we feel we need very badly to extend our research on basic problems of materials. There is, of course, a great deal of basic research on materials going on in this country, both in industry and sponsored by various Government agencies.

However, we find that even basic research on materials is influenced by the final applications that people have in mind. Consequently, materials for space applications do not necessarily receive the attention that they should receive unless other applications are also apparent for them.

Our total effort on this basic materials work will remain small, very small compared with the total effort in the country. All we will attempt to do is specialized work that is not otherwise——

Mr. MILLER. Isn't a great deal of this work done at laboratories throughout the country, industrial laboratories and universities and by the metals companies and others?

Mr. ABBOTT. Yes, sir. There is a great deal of work on materials being done in this country and the amount of it is increasing.

Much of it is supported by industry, such as the metals industry, a very considerable amount of it; much more than we are supporting is being supported by the Department of Defense and the military services. Consequently, we feel that our role in this basic materials work should be only to pick up those problems, and more particularly those materials, which will be needed for space applications, but which do not appear to have other possibilities for applications, and consequently are not being worked upon by other people.

Mr. MILLER. Haven't such institutions as the Bureau of Standards equipment and the know-how for doing this work? Couldn't it be contracted with the Bureau of Standards without spending money? Here you are spending $4 million, a quarter of it for a building. Doesn't the Bureau of Standards have some competency?

Mr. ABBOTT. Yes; they have a considerable amount of competency in this field. We do support work at the Bureau of Standards by transfer of funds. However, the Bureau of Standards is not set up to do work of the magnitude which would be done here. If we wish to have this work done by transfer of funds with the Bureau of Standards either the Department of Commerce or ourselves would have to supply them with comparable equipment.

Mr. MILLER. I appreciate that, Mr. Abbott, but it strikes me in many of these fields, if we were to go into them thoroughly, that we might find work of this nature being done also in the Department of Defense. You are setting money up to do it in NASA. The Government might be able to save if it turned over to an agency like the Bureau of Standards the research and development in certain of these fields so that other agencies of Government could then request that special work be accomplished.

Certainly part of the work that you are going to do here will find its application perhaps in certain things that the Air Force wants to do. Of course, in effect that is what you are, a research agency—you still carry on the old functions of NACA?

Mr. ABBOTT. Yes, sir. I think this is properly one of those functions.

One of the problems in research is this use of single words to classify areas of research. Materials research is one of these cases. There is a great deal of effort going on in this country, as I have said, in materials research. This effort is, however, very well coordinated both informally and by formal means, by interdepartmental groups who examine this materials research and decide who should do what in which areas, and who keep each other thoroughly informed on what is going on.

We ourselves have a materials advisory committee which has people on it from other governmental agencies, from universities and industry. There is not, I believe, any real duplication of effort in this field. The thing that has caused the recent upsurge of interest in materials is that most of the basic materials research which is going on in the country is not too well adapted to modern problems. We are running into areas of new materials, new environments in space and other particular applications. The Atomic Energy Commission has special problems which are not common to industry, in which industry cannot see any way of really making any profit out of these things. Now, I think there are going to be some surprises in this.

This is typical of research. One discovers things and they become applicable in areas that you never dream of.

It does seem to me that having the responsibility for space exploration, NASA has the responsibility to pick up a small part—and it would be a very small part of the total materials research of the country—that is peculiar to our own business and see to it that it is done one way or another. I grant you it can be done either in-house, in our own research centers, or by building up the Bureau of Standards or somebody else. I think it would cost the same however it is done.

Mr. MILLER. The Bureau of Standards has outgrown its present location. We now have a new location for them. We are going to start relocating them out there. They have done a lot of work in this field. You have contracted a lot of work with them. I know the Air Force has.

When they get out there, they will have the only device for measuring large thrusts, I guess you would call it, will they not? You will have to go back to them pretty much. Don't they have the best machine——

Mr. ABBOTT. Large thrust?

Mr. MILLER. For bringing under pressures, 100,000 pounds?

Mr. ABBOTT. They have much special equipment.

Mr. MILLER. It is about the biggest in the country and this is the thing that you have to measure your other thrusts with.

Mr. ABBOTT. I quite agree that it could be done that way. I do not believe this would be the best and most efficient way to do it.

Mr. MILLER. Certainly at this time with the element of time as you put into it, the Bureau of Standards couldn't undertake this at its present location and by the time it gets its new location underway to do the job, we hope we will be out of the woods.

Mr. DUCANDER. In line with your questions, I happened to run across this item for JPL back here, for materials research. Do you have a material research laboratory at JPL?

Mr. ABBOTT. A very small activity at JPL.

Mr. DUCANDER. That couldn't handle this item that we have been talking about?

Mr. ABBOTT. No, sir. Again, I think that any plant or any laboratory such as JPL, which is not primarily a research laboratory but is primarily concerned with the development of vehicles, has to have some materials work going on because they are running into materials problems all the time. They can, of course, and will take most of these problems to other people. But, nevertheless, they cannot, I believe, be deprived of all know-how in materials, and still be expected to go ahead efficiently with the rest of their mission.

Materials are basic to everything. You have to have some materials people around. If you have materials people around, they stay materials people only if they work on that subject.

Mr. DUCANDER. There is a research laboratory at JPL?

Mr. ABBOTT. Yes. It is not as large as the work going on at Lewis which this would expand materially. There is some materials work going on almost everywhere.

General OSTRANDER. This is true also in my area at Huntsville where we will be doing the booster work. We have to have materials

people who are familiar with the types of materials we can use in our vehicles, but they are doing more of an application type of engineering rather than basic research.

Mr. MILLER. Have you something in here for material research at Huntsville?

General OSTRANDER. We have nothing specifically for that. There is a building that includes——

Mr. MILLER. Yours is more the application?

General OSTRANDER. Yes.

Mr. ABBOTT. This is research.

Mr. MILLER. From this will you be in a position, for instance, to get information for Huntsville?

Mr. ABBOTT. Yes, sir. We will expect to support Huntsville and JPL and Goddard and the industry and military insofar as possible.

Mr. MILLER. Do you have any other questions?

Without objection then we will approve that $4,050,000 and that takes care of Lewis.

The next one is on page 335, the Goddard Space Flight Center.

Mr. ABBOTT. I would like to have Mr. Townsend speak to that.

Mr. TOWNSEND. Mr. Chairman, Goddard is the newest center in NASA excluding Huntsville, which will come in July.

Mr. MILLER. Where is Goddard located?

Mr. TOWNSEND. I was just going to tell you. It is near the intersection of Glendale Highway and the Baltimore-Washington Parkway. It is physically next door and includes actually the WWV transmitter site. It is on property that belonged to the Beltsville Agricultural Station. We prefer to call it Greenbelt because that more accurately locates it geographically.

At the present time the Goddard Center has approximately 1,200 people on board. These people are split up in a number of different locations and are housed temporarily. For example, the whole manspace project, Project Mercury, is at Langley. There is a large group located at the Naval Research Laboratory. Another group at the Naval Receiving Station, and finally a small group in Silver Spring. So we are in temporary quarters at the present time.

We are hoping to move into our first two buildings, which were authorized and funds appropriated for them in the 1959 budget, sometime in the month of June or July. The first two will then be ready.

Goddard's mission is in several areas. We are undertaking scientific experimentation in space. This is basic research but it takes place in space itself. We are conducting technological experiments such as the so-called application satellites, the meteorological satellite, the communication satellite, and the geodetic satellite.

As part of it—one of the fundamental projects Goddard is conducting is the Mercury project. We are also responsible for operation of the Minitrack tracking network and for data acquisition from earth satellites.

Basically Goddard's role is in connection with sounding rocket and satellite research which distinguishes it from the other centers.

Goddard was formed actually by taking rather large groups from the NACA and from the Navy and from the Army. Project Vanguard, if you recall, was transferred by the President to become a part of Goddard at the start.

Another rather large group transferred from NRL. People from the Signal Corps transferred into Goddard. In other words, it was started quickly through bringing in already established groups with competencies and with their organizational setups.

The two items that we have proposed this year are additions to our Greenbelt facility, one of which is a payload testing facility and the other is a satellite systems laboratory. That is the introductory part.

Mr. OSMER. I have gone over the material in the ring binder here. It is a very difficult thing. Aside from asking general questions, it is a very difficult thing without an intimate knowledge of these proposed facilities and also facilities that other branches of Government might have. It is a difficult thing to question either the adequacy or the inadequacy or the cost of any of these matters.

I am assuming, having read the backup descriptions in the booklet that has been provided here, it is easy to see that these facilities are needed. It takes a measure of assumption on our part that the facilities and the amounts of money asked for will in fact provide them.

I have no detailed questions.

Mr. MILLER. Mr. Quigley.

Mr. QUIGLEY. Do I understand correctly that the Goddard Space Center at Greenbelt is going to be more or less general headquarters for NASA, to coordinate general information from your various and sundry other installations?

Mr. TOWNSEND. That is not quite correct. Goddard will assist headquarters in the implementation of the national program, in particular, in the area of sounding rocket and satellite research.

We will do research ourselves, but we will also assist by providing personnel to monitor contracts, personnel to coordinate the efforts of the various contractors and in the field operations and personnel in support of such things as tracking and data recovery from satellites.

You might say we have a twofold mission; one, to do a certain amount of research ourselves that is not being done elsewhere, and secondly, to assist in the gathering together of a broad program that is generated and formulated by the NASA headquarters here in Washington.

Mr. QUIGLEY. It is not contemplated that the NASA headquarters administratively speaking would be centered at Greenbelt?

Mr. ABBOTT. No, sir.

General OSTRANDER. I think I might be able to help here if I described the overall relationships within our space program per se as opposed to the research portion of NASA. There are essentially three centers involved in the space program itself. Goddard, as Mr. Townsend says, handles the satellite work, the sounding rocket work; JPL will handle the lunar work and deep space work; the center that reports to me, Huntsville, Dr. von Braun's group, will build the boosters, the launch vehicles to launch the payloads for both Goddard and JPL.

Mr. QUIGLEY. I had the impression when we discussed the appropriation for the Greenbelt installations last year that ultimately I visualized out at Greenbelt a NASA headquarters somewhat similar to the one that we have up on Route 240 for AEC.

Mr. ABBOTT. I think I know the source of your confusion, sir. The intention is to make Goddard the center for data acquisition.

Mr. QUIGLEY. This strikes a note in my memory.

Mr. TOWNSEND. Command and control center.

Mr. ABBOTT. Yes; and for data acquisition from space vehicles, the center of the nets which in some cases are worldwide, of course. But this is quite a different matter from being NASA headquarters. It will be a data center.

Mr. MILLER. There is nothing here—I notice centrifuges to duplicate the other things that you are doing at Langley.

Mr. ABBOTT. No, sir.

Mr. TOWNSEND. Maybe I could speak briefly on these two facilities. The distinguishing point here, I think, is that these two facilities, both of them, will work with the actual satellites that we intend to fly. The facilities described earlier are for basic research on satellite systems, things that are applicable to a large number of projects. These particular facilities, though, will do work on the actual hardware that we put in space.

They are part of an integrated attack on the problem. Actually, the order is wrong here in the book in the sense that we should really consider the satellite systems laboratory first and then the testing which follows the assembly.

We need this satellite systems laboratory to put together what we call our second-generation satellites, our very large and complicated systems such as the Nimbus meteorological satellite, the orbiting astronomical observatory, and the orbiting geophysical laboratory. These objects are rather large in size, 10 to 20 feet, possibly, after they unfold, and will weigh up to several thousand pounds. They are very complicated.

We will not build these at Greenbelt. Actually, they will be built primarily by private industry, a piece here, a piece there, a piece elsewhere, wherever the best competence and capability is.

Many of the experiments, for example, will come from colleges and universities. We will take these pieces and put them together in this facility and check the satellite as an entire system. After we are through assembling it and running our qualifications tests on it to be sure that it is going to work, we will put it in a testing facility and actually expose it to the best possible simulation of the environment we expect.

We will shake it to duplicate the vibration in the launching phase. We will subject it to exposure for a long period of time in high vacuum while the object is being heated and cooled, as it will when it rotates around the earth.

We will simulate other environmental hazards. Incidentally, we will actually build both what we call prototypes and flight articles. The prototypes we will treat very roughly, giving them essentially worse treatment than we expect to make sure we are on the safe side.

The actual payloads will be tested to the levels we expect. We can show by statistics that if we go through with this procedure with a relatively small number, we can have a reasonable confidence these things will work in space. I think there is nothing more tragic than a successful launching and an unsuccessful object in orbit. We can't really afford to build enough satellites; that is, 10 of each type or 100

of each type to really have the confidence that you get when you turn on your radio at home. This is produced in very large quantities. We can't do this. The only way we can establish this level of confidence is to test these things very thoroughly and this facility will do this job.

Mr. QUIGLEY. How many acres do you have at Beltsville?

Mr. TOWNSEND. We will have to get you the exact answer for the record. It is on the order of 500, I believe.

(The information requested is as follows:)

NASA has 553 acres of land at Goddard.

Mr. QUIGLEY. How many acres did you inherit at Langley?

Mr. ABBOTT. Actually we own a small piece of land at Langley. The rest of the land at Langley is occupied on the basis of an agreement with the Air Force. The amount of land occupied I would have to supply for the record. But it is substantially more than 500 acres, I believe.

(The information requested is as follows:)

NASA owns 430 acres, and has an additional 353 acres on permit from the Air Force, for a total of 783 acres.

Mr. TOWNSEND. If you will notice, there is a plot plan for the entire Goddard center on page 343 of the justification document.

You see, we have kind of built it in the center. A lot of that land we need for protection. Essentially we are very worried about radio interference and problems like this and some of these facilities are special in that regard. It is a matter not only of enough land to locate the buildings on, but making sure that something isn't put in next door to you that makes life very difficult. These complicated electronic systems are subject to interference.

Mr. MILLER. I noticed in one of the descriptions of your buildings here, the first building, you provided fallout shelters.

Mr. TOWNSEND. Yes, sir, that came up last year, if you recall. You asked me the same question.

There is a regulation which prescribes fallout shelters in new Federal buildings. This is nothing fancy. A part of the building in the basement is set aside for this purpose. It meets certain minimum standards for safety and we won't use it for other purposes.

Mr. MILLER. Do all the buildings have fallout shelters?

Mr. TOWNSEND. Every one at Goddard has.

Mr. MILLER. How about Langley?

Mr. ABBOTT. This is a general governmentwide regulation. All new buildings must have them except when they are excepted for one reason or another. The existing buildings at the research centers, being old, do not have them. I forget about the ones in this budget. I don't think the shelters are spelled out in the descriptions. They either have them or don't have them, depending on whether or not exceptions were obtained from the regulations. This depends on the type of building and its purpose.

Mr. MILLER. Can we assume unless there is an exception that they pertain to all new buildings contained in here?

Mr. ABBOTT. Yes; all have to have fallout shelters unless an exception is obtained. Sometimes I think you will find it put in the cost breakdown and sometimes you won't.

Mr. MILLER. Are there any other questions on this building, $4,636,000? It is on page 341.

Then we will go to the utility installation for $1,309,000. These are all standard buildings?

Mr. TOWNSEND. Yes, sir.

Mr. MILLER. Power and water——

Mr. TOWNSEND. In last year's budget authorization we asked for the heating plant and funds were appropriated for it. It is in architect-engineering services now and we expect it under construction in a few months. This simply provides for the additional heating equipment that goes into the plant to provide for these new buildings. We had allowed for expansion in the future and it is a matter of getting the bigger boilers and things that are necessary as we go along.

Mr. MILLER. Any questions?

We come to Wallops Island then, $4 million.

The first item is site preparation, buildings, precision interferometer, including transmission system, range rate, subsystem and two angular rate substations. The site preparation and buildings are stylized, I believe.

Major HAMMOND. Yes.

Mr. ABBOTT. Major Hammond will speak to this.

Major HAMMOND. Perhaps a word or two about the Wallops station, Mr. Chairman.

Wallops has been in operation since about 1945 and since that time they have a rather remarkable record of launching some 3,000 sounding vehicles from that station. Its mission, of course, is the support of the launching and the tracking, the derivation of the data from the various sounding vehicles, the upper air research rockets that Dr. Abbott spoke of.

Mr. MILLER. What type of rockets?

Major HAMMOND. These are essentially all types. The current, the new one that will be coming up is the so-called Scout vehicle. It is a solid-propellant rocket. We have launched rather small vehicles, somewhere in the order of 5 inches in diameter up to six-stage vehicles.

Mr. MILLER. How high do you send them?

Major HAMMOND. The normal definition of the sounding rocket as opposed to the space probe is 4,000 miles. It is, of course, a function of the vehicle that you are using. Take, for example, the Aerobee rocket that will be launched out of there soon, which has an operational ceiling somewhere in the order of, I would say, between 100 and 200 miles, depending on the payload and the type of model Aerobee it turns out to be.

Mr. MILLER. These are the probes that you send into space, rockets that you send up to gain data?

Major HAMMOND. Yes, sir. Not only data relative to the properties of the upper atmosphere but they also carry scale models to supplement wind-tunnel testing and so on.

Mr. MILLER. How often do you fire?

Major HAMMOND. I was going to mention that tonight we had scheduled the third large 100-foot spherical balloon that is inflated. It would be visible from the Washington area, of course, if one would look out at about 6:15 at about 20 degrees south of east. It

can be seen in the sky. It will not, however, be launched tonight because the weather would not be good for optical observations.

We launch easily on the average of once a week if not more often, and we do support firings for the Department of Defense, in some cases the Air Force. Their special weapons people have launched some vehicles out of there very recently; the Javelin vehicle.

Mr. MILLER. Do you have stations over which these pass downrange so that you can track them?

Major HAMMOND. With the vertical type probe, which the majority of these are, the trajectory is characterized by essentially an up-and-down type of motion. This means that it we so arrange our instruments essentially around the base from where the vehicle is launched, these quite adequately cover the mission.

However, the downrange shots, for example, the Javelin vehicle that I mentioned a moment ago, would perhaps go a good deal further downrange, perhaps even into the Bermuda area. This is why, incidentally, in the construction of the Mercury network you will find that the Bermuda installation is the only permanent type station that we are putting in. This is because it can support the downrange shots from Wallops Island.

Mr. MILLER. Are we going to duplicate another Canaveral?

Major HAMMOND. No, sir. The type of firings out of here are such that they, of course, could be done out of Canaveral, for example. But the type of research is applicable to the type of work that Langley, for example, does in aerodynamics. As I said, the work is with the sounding rockets, and with models to supplement the work that is done in aerodynamic research in the Langley tunnels.

General OSTRANDER. Since Canaveral comes under my direction as far as NASA is concerned, I might speak to this.

Generally speaking, at Canaveral the things that we launch are tremendously large, complicated, sophisticated, type of vehicles. They take a long preparation. They may be on the stand for months before you launch them. When you launch one of these, you tie up the complex of instrumentation and the whole cape. If we attempt to mix this type of very frequent, small, up-and-down rocket shots with these tremendously complicated and expensive shots, it would interfere with the work we are doing down there. The two don't mix very well.

I think it is economic in the long run to try to keep them separate.

Mr. ABBOTT. I think that Wallops Island compares to Canaveral in about the same way that one of those little vehicles that the mailman use in the suburbs to deliver mail from door to door compares with a 10-ton truck. They are very nice little vehicles, beautiful pieces of equipment, but one would simply not use one for the job of the truck.

Canaveral is too big and complicated to use for these very small shots. It would just complicate things down there no end, and Wallops is just not capable and will never become capable, of doing the work that is done at Canaveral.

Major HAMMOND. I think one further frame of reference to ease this problem is that the manning at Wallops is only about 250 people, you see, as opposed to I don't know how many thousand on the cape.

Mr. ABBOTT. This is about the same as for a typical down range station at the cape.

Mr. MILLER. You do use the Bermuda station? That is also used by the cape; isn't it?

Major HAMMOND. This is a new station that is being put in specifically for Mercury. It is a very important station for the Mercury firing; yes, sir.

Mr. MILLER. You will use it in connection with Wallops, too?

Major HAMMOND. It can be used.

Mr. QUIGLEY. Is Wallops Island a NASA installation?

Major HAMMOND. Yes, sir.

Mr. QUIGLEY. Is it operated under contract or operated by NASA personnel?

Major HAMMOND. NASA personnel. There are some minor contracts out there, such as the grounds and so on are maintained by——

Mr. QUIGLEY. You don't have anything comparable to the Pan American contract?

Major HAMMOND. No, sir.

Mr. MILLER. This is an inhouse installation.

Mr. ABBOTT. It was originally an outpost of the Langley Laboratory and was started in the last days of the last war. The original purpose was to permit us to make aerodynamic tests in the transonic speed range. This went by the board as we went to higher speeds and the place has gradually grown into what it is today.

Mr. QUIGLEY. He said at Wallops they are fired straight up. If they come straight down, I think it would be hard on the equipment and personnel.

Mr. MILLER. Yes, that is what I was thinking.

Major HAMMOND. Not quite straight up, Mr. Quigley.

Mr. MILLER. I understand at White Sands they had to do a lot of calculating to make sure that the missiles did not leave the range as they might kill some cattle off range——

General OSTRANDER. Major Hammond was the project officer out there at the time and he is very conscious of that.

Mr. MILLER. When I was a young man and in the service, we didn't have all these things, but down at Fort Sill I think the only time we ever fired a gun off range we killed two cows.

Mr. HECHLER. Will this help you to have less unknown satellites?

Major HAMMOND. I was afraid you would bring that up again, Mr. Hechler. I would like to add again that that unknown satellite belongs to the Department of Defense and not NASA.

Mr. MILLER. Any other questions on this $1,910,000?

The next one is the Wallops Island operating computer center, $350,000, including the building modification and the air conditioning.

Major HAMMOND. This is a modification of a building, Mr. Chairman.

Mr. MILLER. This is just an additional computer; isn't it?

Major HAMMOND. Yes, sir. The computer itself will be a rental machine. The funds requested here are simply to make it an operable piece of equipment.

Mr. MILLER. Incidentally, I hope that when you get that new computer out at Ames—they were telling me out there they were trying to make deals with Stanford Research Institution and everybody was running around the country trying to borrow and rent other people's computers. Will that help out out there?

Mr. ABBOTT. I think so. This has been almost a normal universal situation with regard to computers.

Mr. MILLER. Then the equipment modernization, $1,740,000, on page 352.

Major HAMMOND. Yes, sir. This is one I would personally plead for quite eloquently; having been in, as General Ostrander pointed out, in the rocket-launching business for some time, I can appreciate the need for this.

I would like particularly to call your attention to the—under the vehicle checkout equipment—the item marked "Airframe and rocket inspection alinement and radiograph equipment." That term "alinement," for example, is very important. Visualize, if you will, six rockets sitting on top of one another. An analogy could be made to holding six cans, all full, stacked up on top of one another, and in moving them at several times the velocity of sound, to keep them from tumbling off one another. I think this emphasizes the need for alinement.

Mr. MILLER. It would look like one of these skyrockets on the Fourth of July.

Major HAMMOND. Yes; and this is not the general idea with this type of work.

Mr. MILLER. Any questions on the $1,740,000?

Mr. Quigley?

Mr. Hechler?

We will go to JPL, $5 million.

Mr. ABBOTT. Colonel Heaton will speak to these facilities.

Mr. MILLER. Didn't we go through a lot of JPL last year?

Colonel HEATON. Yes, sir. Those items are in the process of being constructed. In fact turn to the sheet just preceding page 354. Although it doesn't bear a number, this is a site plan or plot of the Jet Propulsion Laboratory which is in Pasadena, Calif., an adjunct to the California Institute of Technology.

Mr. MILLER. Does California Tech own this?

Colonel HEATON. This is Government owned. As you will recall, it was turned over from the Army to the NASA.

You will note from these sheets the areas crosshatched there. These are the constructions which have been started principally with funds in the 1960 appropriation.

The ones which are shown in black are those for which funds are requested in this budget request.

Mr. MILLER. Is there any duplication at the Jet Propulsion Laboratory with what is taking place at Goddard and Lewis?

Colonel HEATON. No, sir. The only amount of duplication you would find is a very minimal type, and I think we have had allusion to this several times in the testimony today, where you note that such things as materials research, or materials research and development are being conducted at practically every research and development installation you will find in the country, whether it is industrially owned or Government owned.

Again, this particular work in that area, to speak for a moment to the materials item in this request, has to do with testing of those materials which are most directly involved in the specific work which the NASA has assigned to the Jet Propulsion Laboratory.

As General Ostrander mentioned earlier, their principal role in the NASA picture is to carry out our program in deep space problems and particularly the unmanned lunar program.

Their work in the payload field associated with this program has particular demands on materials. These people carry on that work in behalf of the program both for obtaining better materials for use in the program and also to guide themselves in the selection of the materials that will be used. That is an example of where you could say yes, there is a slight amount of duplication in that we have materials work going on at the laboratory and they have materials work going on elsewhere.

The main role of JPL is quite carefully partitioned——

Mr. ABBOTT. There is duplication only in the sense that it is called materials work. But when you get down to the details of what is being done, it is not duplication because the detail work will be different.

Colonel HEATON. Quite different. That is what I meant to convey.

Mr. MILLER. I can see where we may be carrying out a slight duplication in certain work. If you have an outfit out in California and one back here, you would spend more time running back and forth across the country, lose more time and effort, and perhaps retard progress.

As long as there isn't a duplication, that means substantial money perhaps——

Colonel HEATON. That is right.

Mr. ABBOTT. I think it can be compared with the situation in regard to machine tools. If one had a great deal of heavy machining to do, one would take it to an industrial organization and say, "Make this for me."

However, a shop that is concerned very much with making anything must have a variety of machine tools to do the little jobs, themselves.

Mr. MILLER. I would hate to think every time you stripped a thread on a bolt you would have to send it halfway across the country to thread it.

You would save some money on tools, but lose time——

Colonel HEATON. I think perhaps most of all you save some invaluable time.

Mr. MILLER. That has been one of the things that Mr. Osmers particularly expresses. He is not here, having given me his proxy, I will make the point.

Colonel HEATON. Perhaps referring again to the site plan, in the lower lefthand corner is an area noted as zone 4. This is a small section of land which is contiguous to the present JPL area and which, if not acquired at the present time, will shortly be absorbed by civilian type use such as for homes or other installations.

Mr. HECHLER. What is it now being used for?

Colonel HEATON. I believe at the present time it is relatively vacant. You will note the density of construction already existing at the Jet Propulsion Laboratory.

There has been some land acquired fairly recently up at the top of this picture, last year, into which to expand the rocket work to conform to the hazard——

Mr. QUIGLEY. Zone 2, that is up on the hill.

Colonel HEATON. Yes, sir.

Mr. ABBOTT. That is the reason why these lines on the map run around like worm tracks.

Mr. QUIGLEY. That is highway construction, those black lines drawn in there?

Colonel HEATON. They are access roads. They are a means of getting to those spots. The first item here for $60,000 is merely for the acquisition of this one parcel of land which we feel is very important to the future expansion possibilities of the Jet Propulsion Laboratory area into which we have already poured great sums of money.

Mr. MILLER. That is costing better than $15,000 an acre.

Colonel HEATON. Yes.

Mr. MILLER. That is a lot of money.

Colonel HEATON. Yes, but it is extremely important. Because of the enormous investment already there.

Mr. MILLER. What is just across the boundary line, I am not oriented, north I suppose, to the west of that?

Colonel HEATON. To the west?

Mr. MILLER. Well to the left.

Colonel HEATON. It is very precipitous as I recall. There are road nets in that area.

Mr. MILLER. Is that housing, residential property?

Colonel HEATON. The residential housing as I recall, is some little distance over in here, but, of course—this whole area when it was first begun to be used for the Jet Propulsion Laboratory was a wilderness. As years have passed, all areas, particularly this one, have seen building encroaching more and more on these very expensive installations.

We have acute neighborhood problems. One of the best ways to prevent this sort of thing happening is to see that you have a natural closure, natural boundaries to your own held area and to locate your hazardous facilities on your base in such a way that they impose a minimum and acceptable amount of hazard to the surrounding communities and your own installation.

Mr. MILLER. Some of us are familiar with some of these installations, as they are fairly close to home. I am thinking of Moffett Field, which one time was way out in the middle of the marsh, and now we have had to go down and build another naval station in the San Joaquin Valley because you can't fly over this heavily concentrated area.

I am also thinking of an area out in my good friend's district where Lowry Field was one time out in the country and now some people are complaining about the jet noises of Lowry Field.

When Lowry Field was first established, they wouldn't have given you a thank you for the land that they are now paying a lot of money for. That is what you are trying to do here, to seal off this sort of thing.

Colonel HEATON. Yes.

Mr. MILLER. I presume if somebody wanted to put a housing development in that 3 acres, it would be very embarrassing to you.

Colonel HEATON. Yes. This is a sort of a cul de sac as you see, in our own holdings. There is also this fundamental problem of just sheer acreage for places on which to locate buildings.

Mr. QUIGLEY. The potential for expansion at the Jet Propulsion Laboratory is quite limited.

Colonel HEATON. Yes.

Mr. ABBOTT. If you have been there, you noticed that the area at the top of the map—zone 2 and beyond—are steep hills. Over here on the other side there is a wash which is absolutely not usable. There is only a very small area of flat land here, or semiflat land that can be used. This particular area of zone 4 is the only thing useful left in the neighborhood at all.

Mr. MILLER. Is there any objection to this?

Are there any questions?

Mr. QUIGLEY. I have an observation. We are paying through the nose.

Mr. MILLER. Years ago you could have bought it for $15.

Mr. DUCANDER. I would like to know what is the total Government investment in land, equipment and buildings?

Colonel HEATON. We will have to obtain that and provide it for the record.

Mr. DUCANDER. I had called down prior asking for it to be supplied.

Mr. MILLER. That will be supplied for the record.

(The information requested is as follows:)

JPL had assets of $26 million when acquired by NASA. Obligational authority for $7,750,000 has since been provided, bringing the total to $33,750,000.

Mr. MILLER. We will pass over that one. The modernization of laboratory facilities. These are some of the ones that you show on your big map as black lines?

Colonel HEATON. Yes, sir.

Mr. MILLER. I think without looking at these buildings too much, the design of them—we don't hit the money until we get to page 366.

Colonel HEATON. There are a number of items.

Mr. MILLER. The space science laboratory, building utilities, electronic equipment. There is nothing unique about that building?

Colonel HEATON. No, sir.

Mr. MILLER. $500,000.

Colonel HEATON. For the most part it houses the personnel who are being assembled for this particular role of coordination on an international scale.

Mr. MILLER. In the environmental test laboratory, you have an ultrahigh vacuum test chamber, and an accoustical test chamber. The others are utilities and buildings. Any questions on this item?

Addition to the engineering mechanics and design building—$200,000. That is a building.

Utilities, audio and visual equipment. Any questions on that?

Materials research and processing facility, $500,000. That again is buildings, utilities, and research equipment. The research equipment is smaller. The building is the big thing. What about the cost of these buildings? Are you keeping them on a footage basis?

Colonel HEATON. I am sure they are in keeping with construction in this area of the type which is common to that area and suitable——

Mr. MILLER. It is by contract, I presume.

Colonel HEATON. Yes.

Mr. MILLER. Competitive contract.

Colonel HEATON. Yes.

Mr. MILLER. Nothing in any of these buildings that we have gone over so far that would require special inhouse work or anything like that? They are pretty much stylized buildings.

Colonel HEATON. For the most part, these buildings are of standard type construction that house special equipment. The design knowledge for which is in hand, we don't have to invent anything to build these. It is——

Mr. MILLER. There is nothing——

Colonel HEATON. Designers, given the specifications, can have it built.

Mr. MILLER. The publications library, $435,300. Addition to fabrication services building, including building, utilities, and machine tools—$250,000.

Mr. HECHLER. What does the reports group do?

Colonel HEATON. The reports group are responsible for preparation and dissemination of the reports of the research and development activities of the laboratory.

Mr. HECHLER. I was asking this in relation to the construction. Are they suddenly expanding or are they crowded where they are? I am looking at page 366 that it is urgently needed for more space for the reports group.

Colonel HEATON. Because of the fact that space available to this group has not been expanded in keeping with the increased work that is being done at the JPL and the need for a very thorough dissemination of that information.

Mr. ABBOTT. I might add that if any of you have visited out there, and I would urge you do so if you haven't, you will have noticed that the whole laboratory is congested. The whole situation at JPL is one of congestion.

Mr. HECHLER. I just have a constitutional opposition to many reports.

Mr. ABBOTT. By and large reports is the output of NASA. Our main output is information.

Mr. MILLER. Mr. Quigley is the only venturesome person to go down there.

Mr. QUIGLEY. I have been to the area and I agree with you that it is quite congested. It is the only installation in California that it occurred to me that in a short time ought to be looking for space and I was going to suggest that they take a look at West Virginia or Pennsylvania when it comes to relocating. Quite seriously, do you have any long range plans for JPL?

I think they have a real problem as far as space and land is concerned.

Colonel HEATON. I know of no long range plans to acquire an additional annex, you might say, to the Jet Propulsion Laboratory group.

Mr. QUIGLEY. The only way they could do it would be with a space platform.

Mr. MILLER. I might say to my colleague from Pennsylvania before he gets the gentleman from West Virginia too well heated up, you remember last year Judge Chenoweth put his mark on JPL and said he had some nice canyons out there that were available.

Mr. QUIGLEY. They are nice canyons. Quite seriously I think you have a physical factor at JPL which despite its tremendous record of achievement over a generation or better, this thing has just outgrown the fondest dreams of the Cal Tech professors who first started it.

I think there will always be an installation at this particular spot on the map, but——

Mr. MILLER. Just as there will always be a Cal Tech.

Mr. QUIGLEY. I think any long-range program or expansion of JPL almost has to be done at another physical location.

Mr. ABBOTT. I think you are right.

Mr. QUIGLEY. Not necessarily in California——

Mr. ABBOTT. If there is any great increase in facilities, they cannot take place on that site.

Mr. DUCANDER. Down here at the south, is that the bottom of the map——

Colonel HEATON. There is nothing available down there.

Mr. DUCANDER. Is this the last land expansion that you expect at JPL?

Colonel HEATON. It is the last planned at this time. I think it would be the last that we could effect, for the simple reason that the usable land is already occupied by other installations.

Mr. ABBOTT. It is either completely unusable or already filled up.

Mr. DUCANDER. Didn't you get some last year?

Colonel HEATON. That is zone 2.

Mr. QUIGLEY. Doesn't JPL have something at Edwards?

Colonel HEATON. They have a small installation at Edwards. Sixty acres, I believe. This is a small plot where they do work on liquid rocket engines primarily, firing engines such as the 6,000 pounds thrust one.

Mr. HECHLER. Is that expandable?

Colonel HEATON. It is expandable at Edwards Air Force Base if needed.

Mr. HECHLER. Could some of this work be transferred there?

Colonel HEATON. We have looked into that, of course. The answer to our inquiry has been that the principal work that could be transferred there would be of a rocket character. The dominant role of the Jet Propulsion Laboratory in rockets is one of research, which uses rather small rockets. So we are not currently planning to expand this to a degree which will require in the immediate future the building of a facility on a larger area.

Mr. MILLER. It is getting late. Are there any other questions on these items?

Mr. QUIGLEY. I think we are all bothered by the same problem. Whether we would be better off, instead of paying $60,000 for 3 acres there, buying 35 acres somewhere else.

Mr. MILLER. This complements something that you have.

Mr. QUIGLEY. I agree. I think this may be the last bite. The year after you will have to go somewhere else.

Mr. MILLER. We will adjourn until 10 o'clock tomorrow morning. Can you gentlemen be back here again? The next one that we are going to take up—I think we finished the Jet Propulsion Laboratory.

Colonel HEATON. There are several items in the Jet Propulsion Laboratory.

Mr. MILLER. Let's finish that today. I thought we had reached the end.

Colonel HEATON. This was a $2 million item that we just finished. The next one is on page 368, solid propellant facility, with a plot plan on page 369. This is a completion of the work initiated last year in building a more isolated rocket test site adjacent to the Jet Propulsion Laboratory to enable the Jet Propulsion Laboratory to fire slightly larger rockets and to do so without waivers on safety provisions.

The elements in this facility are the standard ones in any solid propellant facility. First one must prepare the oxidizer, it has to be stored, the oxidizer has to be ground and mixed with a fuel into a composite propellant. This material then must be cast in its rocket cases. After the casting, there is the trimming and curing process, the storing process and, of course, the firing.

The elements here are those types of elements.

Mr. MILLER. These buildings have to be separated and protected one from another.

Colonel HEATON. Many of them are reverted or underground with earth fills.

Mr. MILLER. They are pretty much the same type of building that is used in any other place, the same thing down here at Indianhead, only I presume yours will be a little more modern than that.

Colonel HEATON. That is right. Of course, we are working with an explosive.

Mr. ABBOTT. These individual buildings are located in folds of the the hills.

Mr. MILLER. Is there any question on that phase of it?

Mr. HECHLER. I have a general question.

Mr. MILLER. Can that go on later? We have one more item on JPL. There is the antenna range.

Colonel HEATON. And the liquid propellant test cell. It is on page 363 and is next. The story on the liquid propellant test cells is almost precisely the same as that on the solid propellant area completion. Again we are completing what was started last year of the expansion into this remote area where we can conduct hazardous firings.

Mr. MILLER. There again, there is nothing peculiar about this.

Colonel HEATON. No.

Mr. MILLER. It is common to all such installations.

Colonel HEATON. Yes. There is nothing that requires the development of new technology in order to design or construct it. It is rather straightforward and that is why you can do it in 10 months.

Mr. QUIGLEY. Are these generally in zone 2 up on the hill?

Colonel HEATON. Yes.

Mr. MILLER. The last is the antenna range.

Colonel HEATON. The buildings that have been constructed there are obstructing their old antenna range. That plus the expanded demands for precise antenna testing to develop new design criteria for the more advanced antenna are—for the lunar exploration and the deep space problems, this facility is required. It has been carefully sited so that we have the most flexibility and the most use out of the facility.

Mr. MILLER. Any questions on this?

Colonel HEATON. It is a small item.

Mr. MILLER. You had a general question.

Mr. HECHLER. You are doing pretty much the same thing at JPL as at Lewis, aren't you?

Colonel HEATON. Not quite. The work at the Jet Propulsion Laboratory has been concentrated principally on the solid propellants where Lewis concentrates on liquids. And, furthermore, as regards the liquids, Lewis has been devoting their principal attention to the very high energy liquids and the Jet Propulsion Laboratory's efforts are mainly concentrated on the storable type of propellant. There has been a compartmentalization this way and each other knows what the other is doing.

General OSTRANDER. The work at Lewis, I would say, is a more basic research type character where the JPL is more in the application field.

Colonel HEATON. That is very right, particularly in the liquid field.

Mr. ABBOTT. In the liquid field we are trying at Lewis to get out ahead with the liquids of the future. Many of the things that we are working on there will be way ahead of the possible application.

At JPL while there is some aspect of that, they are working more on the storables which are nearer application and they are much more concerned with the application to their own end items.

Mr. MILLER. Then we will meet at 10 in the morning.

In regard to Huntsville, there will be a lot of questions. We will want to know why it is necessary to spend $27 million down there when we have merely changed the name of the team, why we can't continue to use some of the facilities that are there.

Mr. QUIGLEY. Why we need new locker rooms.

General OSTRANDER. I will be here and try to answer that.

Mr. MILLER. They have talked to you about that phase of it.

(Whereupon, at 4:10 p.m., the subcommittee adjourned to reconvene at 10 a.m., Friday, February 19, 1960.)

1961 NASA AUTHORIZATION

FRIDAY, FEBRUARY 19, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE NO. 1,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. George P. Miller (chairman of the subcommittee) presiding.

Mr. MILLER. The committee will be in order.

Let the record show that Mr. Osmers and Mr. Hechler are here. I believe that gives us a majority. We are well represented on the minority side, so we can go ahead.

This morning we are going into the Huntsville phase. Now, this has bothered me and bothered some of the other members. It is going to be a question that we are going to be faced with on the floor and we are going to have to answer.

You gentlemen have to furnish the answer to this question: We transfer a team at Huntsville from the Army to NASA. These people have been working at Huntsville for how long, 10, 15 years, I guess. You no more than get this team transferred than you come in and tell us that you need $27 million for buildings and laboratories at Huntsville. You need a 5- or 6-story administration building; you need a new laboratory.

Is the Army immediately going to expand its program down there and take up the facilities that were used by the Von Braun team? This is the kind of thing that we are going to have to defend and we were laughing about it yesterday, we know the people who are going to raise this question. If you had come in and said: Well, we need so much this year.

But to come in and present us with $27 million now is a big bite and I trust that you are going to justify it. We are going to have to look pretty hard at this and want justification so we can defend the thing both in the full committee and on the floor.

Now, I don't know, Mr. Osmers, on your side now, whether you agree with that statement or not.

Mr. OSMERS. Mr. Chairman, you and I have discussed this situation prior to the hearing today. It seems to me that there will be a special need for justification of this size of expenditure at Huntsville.

I say that with full knowledge that among my other duties in the House, Mr. Chairman, as you know, is membership on the Armed Services Committee and I am, there, on the Real Estate Subcommittee.

The Real Estate Subcommittee of the Armed Services Committee of the House under the law has to pass on the disposition and acquisition of all real estate, buildings, leases, and it makes rather an odd situ-

ation, Mr. Chairman, for me to sit at one end of this corridor as a member of the Real Estate Subcommittee of the Armed Services Committee passing upon the disposal by the Government of millions of dollars worth of property and then to rush a few doors away and approve programs for the construction of facilities in other places.

Now, I recognize that oversimplification in every field has some weaknesses and possibly this is a place where oversimplification could easily apply. However, it will certainly be necessary for this subcommittee to have good, sound reasons for advocating this complete program to the full Committee on Science and Astronautics, and later on, of course, to the House, itself.

Then there is the appropriation process which must follow that, of course. So with that sort of opening, background statement, Mr. Chairman, I suppose we ought to give them a chance to explain it.

Mr. MILLER. Do you have any observations, Mr. Hechler?

Mr. HECHLER. I think the observations of both the chairman and Mr. Osmers are both cogent and realistic.

Mr. DUCANDER. Mr. Chairman.

Mr. MILLER. Mr. Ducander.

Mr. DUCANDER. I think it would be well to keep in mind that there are certain funds in paragraph 7 on page 2, which is the Huntsville facility, which would have been needed by the Army had the Army retained the facility. Isn't that right?

General OSTRANDER. That is correct.

Mr. MILLER. All right, that is fine. That is the kind of thing that we want very definitely. I want to assure you that as far as I am concerned, I am not prejudiced against this program. I realize these things, but I have tried to put in rather sharp and perhaps not too acceptable language because this is the kind of thing we are going to be asked.

Mr. ABBOTT. Mr. Chairman, we recognize this as a most important question which arises very naturally from exactly the reasons that you have stated.

However, there is a good story, there are good reasons for these, there is ample justification in our mind, and I would ask General Ostrander, who is directly responsible for the work there at Huntsville, to speak to this problem.

Mr. MILLER. All right.

Mr. OSMERS. Mr. Chairman, just before General Ostrander begins, I do want to make one more, very brief, observation and that is that when we discuss the Saturn project, we are very close to the heart of the problems that face the Nation in its relative position with other nations in space.

So that we should not be ungenerous with the program on that particular basis, and I know that that isn't your intention.

Mr. MILLER. That is not my intention at all. As a matter of fact, I have personally enough confidence, I will buy what they have here, but I just want some help, and we are going to be the ones that are going to have to carry this thing on the floor, so you have got to do a good job of educating us now, General.

If we start asking critical questions, it is merely because we are acting as devil's advocates to bring out some of this material.

STATEMENT OF MAJ. GEN. DON R. OSTRANDER, DIRECTOR, OFFICE OF LAUNCH VEHICLE PROGRAMS; ACCOMPANIED BY COL. D. H. HEATON, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

General OSTRANDER. All right, sir. Mr. Chairman, I would like, if I may, to make some general remarks with respect to your observations to begin with. These are that all of these items included both at Huntsville and at Patrick are directly and immediately tied to the expediting of the Saturn program.

If the $113 million request, which the President has submitted to Congress for the expediting of the Saturn program, is valid, then we believe these facilities are valid.

And we must have them, if we are to expedite this program by a year as you were told by Dr. von Braun in his testimony.

There is only one item among these 15 items, I believe, which is in any way dependent upon the transfer of the Huntsville facilities from the Army to NASA and I will point this out when I get to it.

As I believe Mr. Osmers mentioned, there was a figure of some $13 million of these funds which were already programed, already included in the Army's 1961 budget.

Mr. MILLER. All right. Could you give us, specifically, I think, a memorandum on that $13 million that was in the Army's budget so that we can have that to offset?

Then, in effect, what you are asking for is if the transfer had not been effected, there would still be this $13 million. So——

General OSTRANDER. Yes, sir. I would point out that these were included in the Army budget prior to expediting the Saturn program.

Mr. MILLER. All right. I think if you can give us a memorandum and a breakdown of that——

Mr. DUCANDER. Yes, sir; that would be very helpful.

Mr. MILLER (continuing). It would be very helpful for the record.

General OSTRANDER. Yes, sir; we will be glad to.

Mr. MILLER. Very well.

(The information requested is as follows:)

Prior to the transfer of the Saturn program from the Department of Defense to the NASA, the Army had planned to request appropriation in fiscal year 1961 for facilities in support of the Saturn program totaling $13 million. Of this amount, $10,750,000 was to go to Huntsville and $2,250,000 to Cape Canaveral as follows:

Huntsville:	
Saturn static test facility	$7,000,000
Dynamic test facility	600,000
Pressure test cell	650,000
Extension to assembly building	2,500,000
Total	10,750,000
Canaveral: Completion of Saturn launch complex	2,500,000
Total	13,000,000

Of these items, the Saturn static test facility funded at $7 million would have provided a standby facility which could have been activated by installing additional equipment at extra cost in case of a catastrophic accident on the existing static test facility. The NASA funding level of $10,800,000 will result in a facility completely equipped for first stage testing. It will provide the additional testing capacity necessary for the accelerated Saturn schedule.

The other facility items at Huntsville and Canaveral had either been proposed to the Army by Dr. von Braun's Development Operations Division or would have

been proposed in fiscal year 1962 under the old Saturn schedule. The need for these items was rendered critical by the problems attendant to the proposed transfer of the Development Operations Division to NASA and the acceleration of Saturn. NASA is increasing the workload on Huntsville not only by the acceleration of Saturn but by placing additional programs under Huntsville direction. Principally, Huntsville will be responsible for overall direction of the Centaur program and of the NASA program to adapt the Air Force Thor and Atlas Agena B vehicles to NASA missions. To carry out these broadened responsibilities within a manpower ceiling of 5,500, the markedly improved working conditions and augmented technical facilities contributed by the additional $7,700,000 of construction at Huntsville is considered mandatory.

General OSTRANDER. Now, as further description in general on these facilities I would point out that they are in somewhat a different category than the research facilities which Dr. Abbott was talking about yesterday. In other words his facilities are, as you pointed out, generally new—something that we are doing for the first time. These facilities on the contrary, are, I would say, more, bigger and better versions of similar facilities that we have built and used before. In other words, we started out many years ago launching small rockets such as the Aerobee that Major Hammond spoke of. We went from there to the intermediate-range ballistic missiles. We needed larger launching facilities, larger static test facilities. The ICBM program, required still larger facilities. We simply had to have more space, larger gantry cranes, heavier launch pads and so on. The facilities, I am here to discuss, in many cases, are a continuation of this trend. They are simply expanding our existing tools to fit a tremendously large program and a tremendously large vehicle, the Saturn. I think perhaps, sir, the best way to start out unless there are other questions on the general subject is to take a look at the Huntsville plat plan which is shown on page 379 of your book, in order to orient you gentlemen as to where these facilities lie.

This plat plan shows the 1,130 acres which under the transfer agreement from the Army to NASA, if approved by Congress, would be transferred to the jurisdiction of NASA. This tract lies in the center of the much larger Redstone Arsenal reservation and is the site of the facilities which Dr. von Braun's group have been using in the past under the Army.

The northern section, on your plat plan, is in general the administrative laboratory shop area, and the portion in the south comprises the static test firing area.

In connection with one item which we will come to later, if you will notice, almost in the center of the top of the plat you will see a building which is labeled "4484" right here [indicating]. This is the current headquarters building of the Army Ballistic Missile Agency, which includes, of course, Dr. von Braun's Development Operation Division as well as some of his laboratories. In connection with the transfer from the Army it was agreed that the Army would share this building with NASA for the time being until such time as NASA could provide additional facilities within their own area to take over Dr. von Braun's administrative and some of his laboratory activities, and this I can get into in more detail when we come to the item.

The items in question are indicated by the small letters in circles which are scattered around the area and I will point these out as we come to each item in turn.

With that as a preamble and with your permission, I would suggest that we simply go through these items one by one and cover the purposes of each.

Mr. MILLER. All right, sir.

The first one starts on page 380, I believe.

General OSTRANDER. Yes, sir.

Mr. MILLER. This is the Saturn static test facility.

General OSTRANDER. The Saturn static test facility is the second such facility which we will have at Huntsville. If you will remember, in order to get the Saturn program going, we modified initially the old Jupiter static test facility, increasing the height and the waterflow to allow us to test the large 1,500,000-pound booster which is used for the Saturn.

With the stepped-up schedule on the Saturn you will remember from Dr. von Braun's testimony that we move the availability of the first operational Saturn up by approximately 1 year. This means, for example, that in calendar year 1962, instead of producing and firing two Saturns, we will have three to handle. In 1963, instead of three we will launch five, and in 1964, instead of four we will have six to handle.

This is the key to the need for this facility and many of our subsequent facilities that we will cover. We need this second facility for two reasons. First of all, simply because at the expedited schedule we are not able to handle on one facility all of the Saturns that we will produce. The other thing is that if we should have an accident on the single existing facility, the effect on the program would be catastrophic. We would simply lose all capability to static test our missiles and it would delay the program by months or even up to a year or more.

The details of this facility you will see on a sketch appearing on page 382. This large structure serves to hoist and to hold the booster in place, a total height of about 205 feet, as I remember, with a 100-ton crane at the top. At the bottom is this flame deflector which is provided with cooling water, and we also have to provide a concrete-lined trench to drain the cooling water into a cooling pond.

In addition to the immediate facility we must also have all of the supporting facilities. We will have next to the actual static test stand a small, 2-story concrete building which will terminate our instrumentation, will contain our control panels, special power generators, switching panels, and so on. Also we need a new blockhouse to contain all of our instrumentation and control equipment. There will also be a certain amount of site work, preparation of the site, access roads, railroads, powerlines, waterlines, and so on.

Mr. MILLER. The total amount of this phase of it is $10,800,000?

General OSTRANDER. Yes, sir.

Mr. MILLER. Tower $1,900,000, deflector trench, site work, and dock storage. The instrumentation control equipment takes up nearly half of it, $4,510,000.

General OSTRANDER. Yes, sir. One question, incidentally, that might come up is why we are unable to use the same blockhouse for both of these static test facilities as we occasionally have done in the past. The answer is very simple. First of all, we need to separate the two facilities so that in case of a blast we don't destroy the other one.

This means that it places the new static facility so far from the blockhouse that we would be unable to run our instrumentation and powerlines and get good data at that distance from the static test stand.

However, even though we were able to do this, the existing blockhouse is simply too small to contain all of the equipment that we need in there.

Mr. MILLER. How much in the existing blockhouse—how much equipment have you got in there, in terms of the cost of the equipment.

General OSTRANDER. In terms of the dollars.

Colonel HEATON. I don't know exactly, but it approximates the value of the equipment to be installed in the new blockhouse—of the order of $4 million.

Mr. MILLER. In other words, then, if you tried to use the same blockhouse that you have, even at the depreciated value, $350 million, and you put this $400 million in, and you did have an unfortunate accident or something, you would be destroying $10 million worth of instrumentation?

Colonel HEATON. That is not quite true, sir, because a blast on one stand would not destroy the instrumentation in the blockhouse.

Mr. MILLER. I mean if you tried to put them in the one basket, that is the chance you would be taking.

Colonel HEATON. No, sir, not as far as the blockhouse is concerned.

General OSTRANDER. The instrumentation within the blockhouse would presumably not be destroyed because this will be protected.

Mr. MILLER. It will be out of service for quite some time.

General OSTRANDER. That is right, as far as the test stand is concerned.

Colonel HEATON. That is right.

Mr. MILLER. And that would delay the whole program.

Colonel HEATON. Indeed.

General OSTRANDER. The important point, however, I think, is that we need to do testing at the increased schedule rate on two missiles, which will require firings on two stands at the same time. You can't use the same instrumentation for both at the same time.

Colonel HEATON. That is right.

Mr. DUCANDER. This is an item that the Army would have had to have had anyway?

General OSTRANDER. Yes, sir, this is one of the items included in the $15 million. Part of it is included.

Colonel HEATON. You might get a question as to why it would cost more for NASA to build a second static test position than the Army. Where we are requesting $10.8 million, they were talking about $7 million. The facility at $7 million would have been limited to a facility which could be activated if necessary in case of an explosion. The one that we are calling for is one which has the additional capability of permitting simultaneous testing both on the first, existing Saturn static test position and on this new static test stand.

Mr. MILLER. And this new one is designed to take this much bigger thrust engine, and all the things that go with it.

General OSTRANDER. It is designed to handle the complete Saturn engine, including the additional thrust that will come with product improvement in the future.

Mr. ABBOTT. And, of course, this change in philosophy from a stand which would be available only for use in emergency to one which would permit simultaneous operation is connected with expediting the Saturn program.

Mr. DUCANDER. Yes, that is very good.

Mr. MILLER. Now, the standby stand would cost then about $7 million.

Mr. ABBOTT. $7 million.

Mr. MILLER. So with the additional $3 million we not only get the stand, we get one which we can use simultaneously?

Mr. ABBOTT. We double our testing capability.

Mr. MILLER. Mr. Hechler?

Mr. HECHLER. I just noticed on page 381 that the blockhouse for tower No. 2 will actually be closer to tower No. 1 than the other blockhouse. Is that correct?

Mr. MILLER. There may be some folds in the ground that don't show on this map.

General OSTRANDER. Closer to the first test stand, Mr. Hechler?

Mr. HECHLER. Yes.

General OSTRANDER. It is somewhat, although I can assure you that this location does comply with the safety distances for blast.

Mr. HECHLER. I am not concerned about safety, I am concerned about economy right now.

General OSTRANDER. Oh, I see.

Colonel HEATON. The key point, of course, here is that it is either a matter of practically doubling the size of a present blockhouse, which in a sense is building a new blockhouse, or building a second blockhouse. They found it no more expensive to build a second blockhouse. This is necessary if you are going to accommodate all this extra instrumentation and control equipment.

Mr. HECHLER. Now, this amount of over $4½ million for instrumentation control equipment, how does that relate in comparison to other facilities? Is this proportionately a larger amount? I wonder if you could explain why that has to be proportionately a larger amount. Would you give us some detail on why the instrumentation and control equipment for Saturn has to be much more expensive?

General OSTRANDER. I can give you some examples, Mr. Hechler. For example, in the Saturn booster we have, as you know, eight engines. This means in effect for every static test we have to multiply by eight times the number of instrumentation lines and the number of tests or the number of sources of data that we run. We have to make arrangements for starting each one of these eight engines separately, we have to take measurements of temperature, pressure, all the other data individually on these eight engines, whereas in the case of, for example, the Jupiter, you are testing only one engine.

Mr. HECHLER. In other words, when we develop Nova and other things in the future, do you think we will be able to reduce the proportion of this instrumentation?

General OSTRANDER. If the configuration finally chosen for the Nova first stage has fewer engines than the eight used in Saturn the instrumentation required for the first stage operation will probably be reduced, but not in proportion to the number of engines. The higher thrust and greater complexity of more advanced vehicles will tend to increase the instrumentation required.

Mr. HECHLER. I just want you to watch your answer because it may come back to haunt you. [Laughter.]

Mr. MILLER. Have you any further questions?

Colonel HEATON. I hope you are satisfied with the answers in regard to the location of the new blockhouse relative to the first static test stand and relative to the new static test stand. The blockhouse must be close enough to the test stand it will service, so that the test going on can be observed and so that the length of cabling is not excessive, as General Ostrander has pointed out. On the other hand you don't want it so close that the blast from a catastrophic failure of the device you are testing will damage the blockhouse. These considerations have determined the location chosen for the new blockhouse.

Mr. HECHLER. So why don't you close blockhouse No. 1?

Colonel HEATON. In the first place, blockhouse No. 1 is already instrumented, the leads are already in existence and it is to be used to test the Saturn on the static test tower No. 1. There would be no point in tearing this one apart to put the same instrumentation in a new blockhouse. Furthermore, the blockhouse for the existing static test tower is much too far from the new static test tower to permit it to be used effectively for the firings on that tower.

Finally, there is the additional point of the lack of space available in the existing blockhouse to accommodate the additional control and data-gathering equipment that must be installed to conduct tests on the second static test position.

Mr. HECHLER. I think you can well understand, relating back to the initial observations of the chairman and Mr. Osmers, why some of these questions would arise about the possibility of utilizing any conceivable facility now at Huntsville under control of the Army for use in Saturn and I think it must be very carefully justified why Saturn needs these new facilities.

General OSTRANDER. I think the key point of this is, first, that we must have two facilities available in order to meet the rate of production of Saturns that we are going into and, secondly, we think it is wise to have two facilities available in case of a catastrophic failure on one of them which would destroy all of our capability unless we had a backup.

Colonel HEATON. All alternative locations and all possibilities of using Army-owned equipment had been thoroughly investigated before the selection was made.

Mr. MILLER. Incidentally, you are going to take over part of this area from the Army. That becomes NASA's then; you are not just a tenant at Huntsville; is that right?

General OSTRANDER. This land does not, I believe, become actual NASA property. We are given right of use and access and are tenants in the sense that certain of the post facilities will continue to be provided by the Army for NASA.

Mr. ABBOTT. The relationship will be the same as it is at Langley, Ames, and Edwards.

Mr. HECHLER. There is a very interesting general question that came up yesterday when we were discussing with General Medaris the transfer of Saturn to NASA. Mr. Mitchell, of Georgia, asked, would it cost more money. General Medaris said definitely. This is the

knowing concern that every Member of Congress has here as to why you could do it cheaper under the Army than under NASA. I realize this involves questions that are larger than the immediate issue we are discussing on page 380, yet I do think that this points up the necessity for justifying this.

Mr. MILLER. Mr. Ducander?

Mr. DUCANDER. No, thank you.

Mr. MILLER. All right. Then we will go on to the next item, which is the central laboratory and office facility.

General OSTRANDER. This, Mr. Chairman, is the item I mentioned as the only item among the 15 which to any degree is dependent upon or a result of the transfer of these facilities from the Army to NASA.

Mr. MILLER. This is building D, I take it, on your general plat?

General OSTRANDER. That is correct; yes, sir.

The existing building which I mentioned earlier currently houses all the headquarters of the Army's Ballistic Missile Agency, including the headquarters of Dr. von Braun's Development Operation Division, as well as some of his laboratories.

The agreement between NASA and the Army was that we would continue to share this space until such time as NASA could provide their own headquarters and laboratory building, allowing this present building to revert completely to the Army.

The purpose of this item in the budget is to provide such a building. The new building will accommodate Dr. von Braun's headquarters, his administrative staff and three laboratories, the Aeroballistic Laboratory, the Research Projects Laboratory, and the staff offices of the Missile Firing Laboratory. Approximately a thousand people will be located in this building.

Mr. MILLER. In stepping up the program, will it become necessary to increase the personnel down there?

General OSTRANDER. So far as the Development Operations Division of Dr. von Braun is concerned, no, sir. At the present time we have put a ceiling of 5,500 people on Dr. von Braun.

Mr. HECHLER. This is 1,000 more than the current?

General OSTRANDER. So far as the technical people are concerned, actually this will be approximately the same. There is the requirement to provide Dr. von Braun with certain administrative support capability which he presently gets from the Army, such things as contracting, legal advice, personnel.

Mr. HECHLER. But, do you need for this administrative personnel almost 20 percent more? This is getting a little bit away from construction, but still it is directly related because if you have to have people, you have to have facilities, and——

Mr. MILLER. That is our only interest in people now, the housing of them.

Mr. HECHLER. I am comparing 5,400 and 5,500, which roughly figuring, comes between 16⅔ percent and 20 percent.

General OSTRANDER. I would like to point out that these are not all purely administrative overhead people. They will include, for example, the contracting people who actually write the contracts for Dr. von Braun with industry. They are an actual part of his operating capability, rather than just overhead.

Mr. HECHLER. I think you ought to give us or someone should give us with some greater precision, the comparison between what the 4,500 people are depending on the Army for now, and what this 1,000 extra people will actually be doing.

General OSTRANDER. All right, sir. I do not have the detailed breakdown here, but we can furnish it to you.

(The information requested is as follows:)

NASA STAFFING AT THE HUNTSVILLE FACILITY

The proposed NASA staffing will provide Dr. von Braun with nearly the same level of capability as he had available under Army management. The Development Operations Division has 4,213 employees. In addition, the Division receives administrative and technical support equivalent to between 1,200 and 1,300 managers from other parts of ABMA and other Army units at Redstone Arsenal. This group is further augmented by 260 Army enlisted personnel assigned to work in the Division.

Under the proposed transfer plan, the buildup of staffing in comparison with the above is as follows:

	Total	To NASA
Development Operations Division	4,213	3,863
Army support	1,250	815
Enlisted personnel	260	
Total	5,723	4,678
To replace personnel staying with the Army		350
Additional administrative and technical support personnel		385
To replace in part enlisted personnel		97
Total		5,500

HUNTSVILLE OFFICE SPACE PROBLEM

It is our understanding that the office space available for the total Redstone Arsenal complex was in critically short supply before the decision to transfer the Development Operations Division to NASA.

In the course of the negotiations, it rapidly became clear that this would be one of the most difficult problems to solve satisfactorily. For this reason, special attention was devoted to this problem by both the Army and NASA. The Army found itself faced with existing office space shortages which require use of substandard, unsatisfactory space, substantial additional staffing requirements to carry out Army programs, including a need to replace a part of the administrative personnel who will transfer to NASA. For example, of the 1,108 personnel in the Army Ballistic Missile Agency, other than the Development Operations Division, approximately 442 will transfer to NASA. Of these, 326 comprise the Technical Materials and Equipment Division which will transfer as an entity. This supply group is housed in warehouse space within the proposed NASA area. The remaining 116 do require office-type space when transferred to NASA. But the office requirements of ABMA totally will not be materially decreased due to the requirement to replace some of the transferred personnel and additional staffing needed to carry on the Army's military missile programs. Of the total NASA requirement of 1,200 people for administrative and technical support of the Development Operations Division, nearly 400 will need to be provided by other than transfer from the Army. This means that outside recruiting by NASA will put additional pressures on an already severe office space situation.

Total NASA office space requirements for administrative and technical support are estimated at 85,000 net square feet for 600 people. In addition, office-laboratory-type space is required for the Aeroballistic Laboratory, the Research Projects Laboratory, and the Missile Firing Laboratory and plans for such additional space were under study by the Army at the time of the transfer decision.

It was not possible to provide both Army and NASA requirements with available office space. For this reason, the office-laboratory building under consideration by the Army for the laboratory groups above was expanded to provide addi-

tional office space and included in the NASA budget. In the interim until construction is completed, the available office space will be shared under crowded conditions and temporary use will be made of scattered blocks of space in temporary or special purpose structures for office space requirements.

Mr. HECHLER. This would be tremendously useful to have because I have a suspicion that your case would be stronger if you could prove it.

Mr. MILLER. General, this may not be a proper question. We may have to get this from the Army, but is the Army going to step up, do you know, its activities, its ballistic activities?

General OSTRANDER. I don't know the details of that point, sir. I suggest that you ask the Army. I believe that they do have a plan to continue their capabilities in this area, but I am unfamiliar with the details of their plans.

Mr. HECHLER. General, couldn't you get some of these facilities from the Army on a reimbursable basis, such things as the cafeteria, office space?

General OSTRANDER. There simply are no other facilities to get from them. We are, in effect, getting the present building on a temporary basis, on loan from the Army. But there simply are no other facilities to provide for our headquarters and——

Mr. HECHLER. You see this is really the key to what worries people about this. Immediately, as soon as you transfer these existing personnel, then you come in for a new building.

Now, this is, I guess, just a matter of strategy. I have been in the executive branch. where they discuss strategy as well as program. I don't know, maybe you fellows would do better if you waited a year before you came in for a new building, because the minute you transfer and you come in for a new building, it looks kind of funny.

General OSTRANDER. Well, sir, I can understand your reaction, but it takes us some 20 months to build this new building and we are convinced that we are going to have to have that additional space.

Mr. DUCANDER. Mr. Chairman.

Mr. MILLER. Yes.

Mr. DUCANDER. Isn't it a fact that the headquarters building at Redstone right now is overcrowded?

General OSTRANDER. Yes, sir; it is extremely overcrowded.

Mr. DUCANDER. Isn't it a probability at least, had they retained this project, they would have had to ask for funds to build an additional building?

General OSTRANDER. With the increase in the program, I would guess that they certainly would have had to have additional space. One point which I did not make is that a part of the need for the additional space is, again, a direct result of this expedited program, since the work of these three laboratories that I mentioned, the Aeroballistic Laboratory, Research Projects Laboratory, and the Missile Firing Laboratory, will be increased as a direct result of the step-up in the Saturn program.

Mr. DUCANDER. I think that is very important, Mr. Chairman. In fact, this expediting is causing a difference in the program than what the Army would have done had they retained it and not expedited it.

General OSTRANDER. That is right. However, if they expedited, they would——

Mr. DUCANDER. They would have had to have these very same things.

General OSTRANDER. That is right.

Mr. MILLER. If the Army would have had to increase the staff even by 1,000 to expedite it, they would be up against the same situation that you are up against, as far as housing is concerned.

I remember distinctly on my one visit to Redstone Arsenal that the administration building was bursting at the seams.

Mr. CHENOWETH. Is there housing involved in this?

General OSTRANDER. No, sir; office and laboratory space.

Mr. CHENOWETH. What will be the difference in the personnel situation after this changeover, as between NASA and the Army? The Army is going to retain some of their work?

General OSTRANDER. Yes, sir; we will have a total of 5,500 people.

Mr. CHENOWETH. The Army will have 5,500?

General OSTRANDER. No, sir; we in NASA.

Mr. CHENOWETH. NASA will have 5,500?

General OSTRANDER. Yes.

Mr. CHENOWETH. You don't have anything there now?

General OSTRANDER. All that we have or will have at the time of the transfer are the people which will be transferred from the Army.

Mr. CHENOWETH. Those people are there now then?

General OSTRANDER. Yes, sir.

Mr. CHENOWETH. It is just you put them off of one payroll onto another?

General OSTRANDER. That is right.

Mr. CHENOWETH. Just a paper transaction.

General OSTRANDER. Right; plus some recruiting to bring the manpower complement up to the 5,500 ceiling.

Mr. CHENOWETH. Will NASA bring in new people there, not there now?

General OSTRANDER. Only to a limited degree.

Mr. CHENOWETH. How many would you say?

General OSTRANDER. There are about 400 that I remember; thereabouts.

Mr. CHENOWETH. They will bring in 400 new employees?

General OSTRANDER. Yes, sir; they will be recruited from outside and be brought in.

Mr. CHENOWETH. They are not employees that they have now?

General OSTRANDER. No, sir.

Mr. CHENOWETH. These will be entirely new people?

General OSTRANDER. Yes, sir.

Mr. CHENOWETH. What type of people?

General OSTRANDER. These are in general contracting people, legal people, the support-type people to back up the technical operations.

Mr. MILLER. The General Services Administration of the Army, Judge Advocate General, that sort of thing, they furnish these things for the Army. They are doing this for the present setup.

Mr. DUCANDER. That is a good question, will this decrease the Army payroll down?

Mr. MILLER. That is something——

Mr. DUCANDER. Maybe we had better get an Army witness on that question.

Mr. MILLER. That is something we don't know. They can always say, if they have some either civilian or judge advocate general officers down there doing this sort of thing, that they have always got use for them someplace else.

Mr. HECHLER. Maybe we can give Mr. Osmers a few buildings to dispose of. [Laughter.]

Mr. CHENOWETH. I am trying to find out just what the impact is going to be at Redstone in view of this change of administration, change of building.

Mr. MILLER. Judge, there will be an impact due to change of responsibility to the setting up of this new organization, and on top of that, the thing we have got to consider is the fact that we are stepping up this Saturn program——

Mr. CHENOWETH. Yes, I understand.

Mr. MILLER. By a year, which means new emphasis in it, new facilities required if we are going to do this.

Mr. CHENOWETH. New manpower, additional manpower.

Mr. MILLER. Not only new manpower, but new facilities, and that is the thing we are talking about now.

In other words, this—right now we are talking about a $4,400,000 building with all of the facilities, site preparation, and roadways. The building itself costs about $3,485,000. The other $1 million for the things that go into such buildings, design and engineering, collateral equipment, communications, and utilities. We were determining the necessity for this building.

Presently this building shown here [indicating] is the headquarters of the Army's ballistic missile group and part of Dr. Von Braun's staff and facilities are located in here [indicating]; this building is one that we know, you and I have seen, is bursting at the seams now.

Now, whether this change had been made or not, and the Army was still going to continue the program and you were going to step it up a year, they would have to do a lot of expansion.

So what we are talking about now is building this building [indicating]. That will take over the functions of NASA.

Mr. CHENOWETH. I see.

Mr. MILLER. And relieve the Army over here [indicating], and this is one, I assume—and it is a pretty safe assumption—that the Army would have had to come in and ask for this building had the team not been taken over, or ask for a building, it may not have been this building, because now this building has to house many of the functions that the service corps of the Army, Judge Advocate General, engineers and all of this supply as part of the Army will now have to be set up within NASA itself.

Mr. CHENOWETH. NASA will have its own separate building.

Mr. MILLER. That is what we are talking about. This is the building.

Mr. CHENOWETH. Army people will be in a separate building, there will be no connection between the two.

General OSTRANDER. No, sir.

Mr. ABBOTT. There should be another point made here. That is the reason it is possible to step up the Saturn program that is planned, maintaining this level of 5,500 people down there, is that certain of Von Braun's missions, or Von Braun's group, which they now have

will be phased out or greatly reduced. These include certain missions, technical missions with regard to other Army weapon programs.

It may be necessary for the Army, itself, to otherwise pick up some of these with their activities. Other missions include supporting research activities which will be reduced or phased out completley, depending on their nature, and for which the Von Braun group will depend to a large extent on the other research facilities of the country, primarily NASA research centers.

So there will be a considerable change in the character of the work in a peripheral nature; that is, not the basic character. So that to a very much greater extent than previously, the main emphasis of this group will be on the Saturn and other NASA programs.

Mr. MILLER. The Army, though, is still maintaining its own facilities down there on its behalf?

Mr. ABBOTT. The Army does have some weapons programs which they have to continue.

Mr. MILLER. Which is their business?

Mr. ABBOTT. Which is their business.

Mr. MILLER. Not ours.

General OSTRANDER. They have been done in the past by Dr. von Braun. One other point I should make is that I was down there just a week or two ago and I spent some time with Dr. von Braun actually reviewing and making a personal inspection for other available facilities, or other available space, and there simply isn't any.

Mr. ABBOTT. No.

Mr. CHENOWETH. The Redstone Arsenal has other activities besides the missile. That is an old ordnance depot, isn't it, Redstone Arsenal?

General OSTRANDER. The main job so far as the Army is concerned right now is in the missile field, but it includes not only the research and development business, but also some of their logistics functions.

Mr. CHENOWETH. What was it originally built for?

General OSTRANDER. It was originally built as two installations, one was a chemical warfare arsenal and the other an ordnance arsenal.

Mr. CHENOWETH. Storage?

General OSTRANDER. Storage and I believe some production. I am not too sure on this.

Mr. CHENOWETH. How far back does it go?

Mr. MILLER. About World War I, doesn't it?

Mr. ABBOTT. No; World War II.

General OSTRANDER. Early World War II, I believe.

Mr. CHENOWETH. What is the normal strength of Redstone? Leave out the missile. Before the missile people came in, it was a pretty good sized installation then?

General OSTRANDER. Yes; but I don't know the figures.

Mr. CHENOWETH. When did the Von Braun team move in?

General OSTRANDER. 1950.

Mr. CHENOWETH. Construction work was done then to take care of them?

General OSTRANDER. Yes, sir.

Mr. CHENOWETH. Now, that is all filled up and you need more?

General OSTRANDER. That is right.

Mr. CHENOWETH. As I get it, only about 400 or 500 new employees will go to Redstone as a result of this transfer?

General OSTRANDER. Approximately that, yes, sir; other than the ones that are transferred from the Army payroll to NASA.

Mr. CHENOWETH. That will be new employees?

General OSTRANDER. Yes, sir.

Mr. CHENOWETH. Where will you house them?

General OSTRANDER. These in large part would go into this new building.

Mr. CHENOWETH. I mean the housing.

General OSTRANDER. Living? They would live in or around the town of Huntsville.

Mr. CHENOWETH. They would have to live in Huntsville?

General OSTRANDER. Yes, sir.

Mr. MILLER. There is no housing——

Mr. CHENOWETH. No housing on the base?

Mr. MILLER. No, sir; there is military housing for military personnel, but none for civilian employees.

Mr. CHENOWETH. They will have to go to Huntsville?

General OSTRANDER. Yes, sir.

Mr. CHENOWETH. What is the picture there?

Mr. GLEASON. It is all right, sir. There is housing in the city. At least that is what the chamber of commerce tells us.

Mr. MILLER. That would be up to the city and the other people, Public Housing Administration and that sort of thing which would not concern us.

Mr. CHENOWETH. This transfer is going to be made when, April 1?

Mr. MILLER. July 1?

General OSTRANDER. July 1 will be the official transfer date. In the meantime, assuming that Congress approves this request, we will be making all of the plans. It is easier to transfer on July 1 because of the fiscal financial arrangements.

Mr. MILLER. When will you have this new building?

General OSTRANDER. In 20 months on this particular building.

Mr. CHENOWETH. Is it going to be a pretty crowded, congested situation up until that time?

General OSTRANDER. It certainly will; yes, sir.

Mr. CHENOWETH. Nothing you can do about it?

General OSTRANDER. I don't know of a thing other than to expedite the building of this building just as fast as we can.

Mr. MILLER. Any further questions?

Mr. CHENOWETH. No.

Mr. MILLER. All right. We will go on to the next one, "Dynamic test facility."

General OSTRANDER. This, again, is very closely tied to the Saturn program. Now, this facility is shown on page 391 and the purpose of it is to be able to erect the entire Saturn missile, including the three stages—the present Saturn booster and the upper stages which are powered by hydrogen and oxygen—and to check out both in a fixed position, as it would be when mounted on the launch stand, and also in a free position, suspended from cables, which would simulate the conditions which the missile would undergo in actual flight. In other words, we can set the Saturn up on a base and we can check out the release arms which hold down the vehicle and release at the time of launch; we can check out fueling techniques, for example; we can work out methods for ground crew training for assembly.

I think a very good explanation of the need for this was the analogy that Major Hammond gave yesterday on this problem of alinement, where you have the tin cans sitting on top of each other. In this case you have tin cans, the largest of which is 70 feet long and 21 feet in diameter, the upper two contain liquid oxygen and liquid hydrogen at temperatures of down to minus 100° F. All of this is pushed at the base by 1,500,000 pounds of thrust with temperatures at the 3,000° C. level. So that the problems of precise alinement of these sections and the problems of bending moments and the resulting stresses due to maneuvers or windgusts in flight place stringent demands on vehicle structure. The primary reason for the design of this facility is to simulate these conditions as nearly as possible on the ground, to insure the structural adequacy of the vehicle before it is flown. It is a ground simulator for flight conditions.

Mr. DUCANDER. This couldn't be done on a test stand, could it?

General OSTRANDER. No, sir. The problem on a firing stand is that there you must have the vehicle fixed in position. In order to simulate the conditions of flight you must have it as nearly as possible free in space. In this case we are able to suspend the missile on cables and then test its reaction to imposed forces.

Mr. ABBOTT. I think it might be noted that this dynamic test facility was also one of the facilities orginally budgeted in the Department of Defense in support of the Saturn project.

Mr. HECHLER. I understand there are several different version of the Saturn and I wonder if this facility is going to be useful for all different versions of the Saturn.

General OSTRANDER. This is for the first or so-called C–1 version. However, you will notice on your sketch on page 391 that as we go into the later and larger versions, this is capable of extension upward to take care of the larger version.

Mr. HECHLER. Could you elaborate a little bit on what that would involve, the extension upward, in terms of general—not specific costs, but the general work that needs to be done on it.

General OSTRANDER. I can't give you any very good estimates on cost at the present.

Mr. HECHLER. I don't mean cost, I mean just what in general, physically?

General OSTRANDER. Yes, sir. It simply means extending the steel structure by about three more bays, which this is just standard commercial steelwork, and then placing your crane on the top of this structure.

Mr. HECHLER. What we are concerned about, of course, is whether adequate preparation is being made for the future, whether this would mean entirely new structure or not.

General OSTRANDER. All of the foundation and all of the existing steelwork is designed to take the stresses required when you extend it to take the final version of Saturn.

Mr. MILLER. That I think is the usual procedure.

General OSTRANDER. Yes, sir.

Mr. MILLER. Any further questions?

Mr. HECHLER. No.

Mr. DUCANDER. No, sir.

Mr. MILLER. All right. We will go on to the next one, the pressure test cell, $650,000.

General OSTRANDER. This again is directly connected to the Saturn program and again is one of the items which would have been included in the Army 1961 budget.

This is simply a room, a strongly built room in which we can run tests at the high pressures which are involved in the vehicle, both hydraulic and gas pressures, to determine that our structure in the missile is sufficient to withstand the pressures for which it is designed. We have to have a separate room and a strongly built room so that in case of a failure it won't destroy the building.

Mr. MILLER. Any questions?

Mr. DUCANDER. No.

Mr. HECHLER. No, sir.

Mr. MILLER. We will go on to the next one, "Extension of the assembly building."

General OSTRANDER. This is one of the items which I mentioned at the outset where we are simply faced with conducting familiar operations on a greatly enlarged scale. As you know the first stage of the Saturn has been designed, developed and is being built by Dr. von Braun's people at Huntsville. They have currently limited assembly space to put the parts of the vehicle together. In the past they have been working on smaller missiles, the Jupiter, the Pershing, so on. We simply are running out of places to assemble the much larger Saturn vehicle.

You will notice on page 397 that this is an extension or a section joining two of our existing assembly buildings, so that it will make available both the existing space and additional space which is shown in black.

Mr. MILLER. Where is this building on the master plan? Is this Building C?

General OSTRANDER. Yes, sir. C, which is in the upper left-hand corner.

Incidentally, there is a list in the lower left-hand corner of your plat plan of these various items. It lists all of them, I think, with the exception of the last one which we will come to. This, in addition to our checkout building, is also located at point B in the upper left.

Mr. ABBOTT. It should perhaps again be noted that this was one of the items originally included in the Army budget.

General OSTRANDER. Yes, sir; that is correct.

Mr. DUCANDER. Yes.

Mr. MILLER. This is for $2½ million.

General OSTRANDER. This will give us approximately 77,000 additional square feet of assembly area.

Mr. MILLER. Incidentally, I was going to suggest that in the future I think that in the case of buildings it would be well to show in the backup book the areas, number of square feet that you are going to get in buildings.

General OSTRANDER. These data are listed on page 396. Unfortunately we didn't total it, but it does come to that——

Mr. MILLER. That is all right. I say generally in the case of the other services before the Armed Services Committee this is always a requirement, the square footage of the buildings and quite frequently

the historic costs for installations and buildings are shown and the things that you are adding to them so that sooner or later, I imagine, we will have to go into those things here so that we know the overall story of costs at Huntsville, Canaveral, or any of the facilities, so that we know what we are adding to them or what we are taking away from them.

I would suggest that for the future you talk to Mr. Ducander. I am certain he could advise you as to what the practices have been over there. I think we will want to follow pretty much the same practices here.

Mr. ABBOTT. Yes, sir.

General OSTRANDER. Yes, sir.

Mr. MILLER. Have you any questions?

Mr. HECHLER. As I understand it, when the Army worked on Jupiter it contracted out with private industry for the assembly of some of the vehicles.

General OSTRANDER. Yes, sir.

Mr. HECHLER. I just wondered whether the Saturn program was going to be worked in any respect the same as that, or what is your overall philosophy about that?

General OSTRANDER. At some rate of production it may be desirable to go out on contract for the first stage of Saturn. The first stage, incidentally, is the only part of the program which will be actually fabricated at Huntsville. The upper two stages will be on contract to industry.

At the present time because of the relatively low rate of production, we don't feel that it would be economical to contract for first-stage production. For example, if we went out right now and attempted to get a commercial firm to produce this stage, rather than continue to produce it at Huntsville, my guess is, and I wouldn't want to be held to this figure, that we would probably have to pay something in the neighborhood of $50 to $60 million for facilities to set up industry to be able to produce this stage.

Mr. HECHLER. I ask this question to relate it to the specific construction request for this assembly building to discover what your future overall plans are as related to this assembly building. This assembly building in the future will provide sufficient space for assembly of Saturn vehicles, is that right? Or how does this relate to your contractual plans?

General OSTRANDER. It will provide us sufficient assembly space to meet the current program through the development of six vehicles a year, which is the most that we reach in the present program. If we go much beyond that we would presumably have to go to industry or have additional fabrication space here. I think our decision as to whether to continue to fabricate them at Huntsville or go to industry will depend very largely, as time goes on, on our total requirements for Saturns. In other words, if the program gets large enough, then it will probably make it economically desirable to go to industry.

Mr. HECHLER. In presenting this budget for the assembly building you have taken into consideration this overall relationship?

General OSTRANDER. Yes, sir.

Mr. MILLER. All right. That is the $2,500,000. The next one is the addition to the engineering building.

General OSTRANDER. This, again, is primarily a result of the stepped up activity in connection with Saturn. This is the building in which we do all of our so-called structures and mechanics work. It is where we do our feasibility and design studies on missile structures, where we do research and development and design of propulsion systems and propellant-feed systems and so on.

The current building in which these people are located has only about 32,000 usable square feet of space. We have about 600 people in that building, which means that there is an average of about 50 square feet per person. That is about the size of this table, I should think. Again the problem is one of congestion. We just must have more space for these people to work with the stepped up program.

It involves, as you can see, an addition or a connection from the existing facilities at the second floor level to a new five-story building which is located somewhat to the east of the present building. And also the people that are assigned to this laboratory currently are located in various buildings scattered around as far as half a mile from the central building.

With the construction of these new facilities we will still have only 120 square feet per person.

Mr. DUCANDER. Doesn't that seem like a long time, 15 months, to build an addition like this?

General OSTRANDER. Based on my experience with this kind of construction I would think this would be fairly optimistic.

Mr. DUCANDER. Is that right?

Mr. HECHLER. Are you through?

Mr. DUCANDER. Yes, sir.

Mr. HECHLER. As I look at this chart on page 400—is that a chart?

Mr. MILLER. The black is the new building, the hatched is the bituminous pavement, parking area. This dotted portion is the addition to the building.

Mr. HECHLER. It seems to me to be a rather slender threat connecting the proposed building with the existing building which to my mind I wonder whether you could justifiably call it an addition. I know it sounds good to call it an addition.

Mr. ABBOTT. I am afraid the addition is more functional than physical.

Mr. HECHLER. It is sort of like saying, when you build an underground tunnel between the Capitol and House Office Building, that it is an addition to the Capitol?

General OSTRANDER. I am afraid I can't answer as to why the building was laid out in this way.

Mr. HECHLER. I am not challenging how it was laid out. I am just wondering whether it is a new building.

Mr. MILLER. It is a new building—a rose by any other name is just as sweet.

General OSTRANDER. It is an addition in the sense that the same people will use both buildings for the same functions.

Mr. MILLER. Have you any other observations?

Mr. HECHLER. No, Mr. Chairman.

Mr. DUCANDER. No, Mr. Chairman.

Mr. MILLER. All right. We will go on then to the "Completion of the guidance and control building."

This, I trust, we can call an addition.

General OSTRANDER. Yes, sir; I think this is more nearly an addition that ties to the existing building. This is almost exactly the same circumstance as in the previous item. In this guidance and control laboratory we develop all of our inertia and radio guidance systems.

Here we have our laboratories for infrared and optics and photo work. We do a certain amount of work on solar batteries for powering the equipment in satellites, on microwave components, on our tracking systems, and our hydraulic servomechanisms. Here again in the existing facility we are simply running out of space, and with the increased tempo of the program we are going to have to have more.

In addition there is a certain amount of reorientation in the type of work, the detail of the work that these people do. In the past they have been building guidance systems for military vehicles which—I probably wouldn't have said this when I was working on them—are sometimes relatively simple compared to the precise guidance systems that we need for some of our space vehicles. In addition we get into the problems of the actual control and stabilization of the space vehicle, itself. So there is a certain amount of reorientation in the work, but in general it is simply a matter of the program expanding, as a result of which we are running out of laboratory space.

Mr. MILLER. Well, as an old engineer since World War I, when I was out to NASA at the Ames Laboratory they showed me a platform they were building which had to be stabilized within one-tenth of 1 second of arc. I remember reading for years if you could turn an angle into degrees sometimes down to 15 minutes, you thought you were doing pretty good, but when they told me they had to stabilize this thing within one-tenth of 1 second, that is remarkable. I think it is part of the satellite that they will use to take astronomical pictures. I suppose you are familiar with that.

General OSTRANDER. Yes, sir.

Mr. MILLER. I quit on refinement there. [Laughter.]

Incidentally, about one-tenth of 1 second would be the angle subtended by 18 inches at the end of a radius of 400 miles or so.

General OSTRANDER. These people have to work to some amazing accuracies.

Mr. MILLER. So you get down pretty fine.

Mr. ABBOTT. This is why you find that at the Ames Laboratory, which is a research laboratory, where we are trying to find out how this sort of thing can be done. In the final analysis it will be necessary for this to be done by industry or by places like Huntsville or Goddard or others.

Mr. MILLER. When you get down into that stuff, my friend, as far as I am concerned, you can do it inhouse, in the Government, better than they can in other places.

Mr. ABBOTT. Yes; some can be done in one way better and others in another way.

Mr. MILLER. I will go along with doing it in our own laboratory. This is the kind of probing and pioneering that you can't do under the gun and under the impetus of making a profit. The guys who do this have to be pretty dedicated guys in my book.

All right, then, we will go on to the addition to the fabrication laboratory. Do you have any questions?

Mr. DUCANDER. No, sir.

Mr. MILLER. I won't ask you each time; if you have anything, you come in.

Mr. DUCANDER. Yes, sir.

Mr. MILLER. Addition to the fabricating laboratory. This is pretty much, I assume, the same story.

General OSTRANDER. Exactly the same story, and relates almost directly to the remarks that I made on the assembly building. This is the laboratory building in which we actually fabricate, actually make, the parts of the Saturn and then in turn assemble them in the assembly building. Here we need more space because of the bigger vehicle.

Mr. MILLER. The next one is the addition to the checkout building. This comes into a pretty good sum of money, $4½ million.

General OSTRANDER. This is the third in the series of buildings required as a result of the Saturn buildup. First, the fabrication building in which we build the parts; second, the assembly building in which we assemble them; and third, the checkout building. In this building we are able to put a complete Saturn vehicle and simulate on the ground, first, the mating of the hydraulic lines, electric lines, and tankage itself, and then completely check out on the ground the operation of both the propulsion equipment and the guidance equipment included in the vehicle short of firing the engines.

It is in this building that the vehicle is finally ground checked before it is taken to Canaveral and launched. This, again, is purely a matter of having sufficient space and sufficient equipment in order to house and check out these large vehicles.

Mr. MILLER. Of course, this has got to be a pretty good-sized building.

General OSTRANDER. Yes, sir.

Mr. DUCANDER. It holds the whole Saturn in it, doesn't it?

General OSTRANDER. Yes, sir. The whole Saturn will, in the first configuration, be something in excess of 150 feet long, 20 feet in diameter, and some versions get even longer.

Mr. MILLER. How about the size of the building? What is the size?

General OSTRANDER. The new addition is about 200 feet—a 200-foot extension of the building that you see on page 411–2.

Mr. ABBOTT. 110,00 square feet.

General OSTRANDER. 110,000 square feet.

Mr. MILLER. Where is that on the plat?

General OSTRANDER. On the plat plan this is the one which is not shown but which I mentioned is located at the same point as B in the upper left-hand corner.

Mr. MILLER. B; that is the one.

And, of course, this building would be one that would have had to have been built anyway?

General OSTRANDER. Yes, sir.

Mr. MILLER. Although this wasn't in the Army funding.

General OSTRANDER. No, sir; this one was not in the Army funding.

Mr. ABBOTT. The original Army funding was connected with the program as conceived at that time before the step-up.

Mr. MILLER. Before; yes.

Well, that takes care of Huntsville.

Mr. DUCANDER. Yes.

Mr. MILLER. So you know the type of things that we want, things we need to support this budget.

General OSTRANDER. Yes, sir.

Now, we move to Cape Canaveral.

On page 412 you have the plat plan of Cape Canaveral itself, which I am sure you are familiar with. The two areas that we are concerned with today are in the extreme upper portion of the map and in about the center part of the map where the little inset is shown. The first item, which is the Saturn launch complex, is located in the far northern or far top portion, and this consists of completing the Saturn launch complex which is currently under construction. Now, the reason that we have run into need for additional funds on this is primarily because at the time that the Saturn launch complex was designed and initiated, the exact configuration of the upper stages, not the first stage, but the two upper stages, was not yet firm. Since that time the upper stage configuration has been firmed up and it will use, as I mentioned, hydrogen-oxygen propulsion systems. We were not able to define in detail the exact instrumentation and checkout equipment, nor were we able to anticipate certain auxiliary requirements such as hydrogen storage until this configuration was firmed up.

This additional money, $2,250,000, is for the purpose of providing this additional equipment, now that it has been defined.

Mr. DUCANDER. Again, the Army would have had to have spent this money.

General OSTRANDER. Yes, sir.

Mr. ABBOTT. As a matter of fact, this item was included originally in the Army budget.

Mr. MILLER. All right; the same thing that you are going to do with Huntsville, show for Canaveral. If the Army did fund it, let's have it, because that would be helpful to us.

General OSTRANDER. Yes, sir.

Mr. DUCANDER. I notice as we go along that there is a new Saturn launching complex. You are going to have two, then?

General OSTRANDER. We are going to have two. This is based on the same concept as the static test stands at Huntsville.

Mr. DUCANDER. Yes; because it would be catastrophic, as you said before, if one of them was blown up and then you didn't have another one or backup.

Mr. MILLER. That is right.

General OSTRANDER. Yes, sir.

Mr. MILLER. The next item here is the escape mechanism, $300,000.

General OSTRANDER. Now, this and the following item, which is the hydrogen storage and fueling system, are some of the auxiliary facilities which we simply could not define at the time of the design of the original launch complex. The escape mechanism is required because these people are working on what is essentially a 30-story building. They are working around a missile fueled with hydrogen and oxygen which is an extremely flammable and explosive mixture. If

they had to rely upon existing elevators, ladders, or other means of escape, they could not escape in time in case a fire broke out. This mechanism consists of an endless belt with a series of platforms upon which the people working on these five upper servicing platforms can hop on and be transported rapidly downward to the base of the tower, at which time they fall on an endless conveyor belt and are carried well away from the fire area at the base of the tower.

Mr. MILLER. It is one of those things—it is a probability of escape if anything does happen?

General OSTRANDER. Pardon, sir?

Mr. MILLER. I say, the probability of escape—if anything does happen—is there.

General OSTRANDER. I think with this the probability would be very good, but without it they would just be caught.

Mr. MILLER. Without it they are gone?

General OSTRANDER. Yes, sir.

Mr. MILLER. Even with it, it is rough?

General OSTRANDER. It is rough; but I think we could probably get all of our people out.

Mr. MILLER. Hydrogen system; this is the story—handling of hydrogen.

General OSTRANDER. Yes, sir. This is required because of the decision to use hydrogen and oxygen engines in the upper two stages.

Mr. MILLER. Do you have anything?

Mr. DUCANDER. No. It is obvious that is necessary.

Mr. MILLER. Now, the new Saturn launching complex.

General OSTRANDER. This, as I say, sir, is based exactly on the same philosophy that we use at Huntsville on our static test stand. First of all we must have it if we are to meet the launch schedule under the expedited Saturn program. Our launch rate builds up to a rate of six per year. These vehicles have to be on the stand for a period of 3 to 4 months for checkout before they are launched and we simply can't launch the vehicles that we are going to build without two stands. In addition, there is this question of backup in case of a catastrophic explosion.

Mr. MILLER. And this is brought about, too, by stepping up the program?

General OSTRANDER. Yes, sir. It is a direct result of that.

Mr. DUCANDER. Even so, probably you would have to have it, wouldn't you, if you wanted to take care of the accident that might happen?

General OSTRANDER. It would be highly desirable. If you wanted to avoid a probable year or more delay to your program, it is very desirable to have it.

Mr. MILLER. You just got back in time. We are on this $21 million item.

Mr. HECHLER. Yes.

Mr. MILLER. What is the—railroad and service structure, I see——

General OSTRANDER. If you will look on page 415–10, this entire servicing structure which surrounds the missile during the time of preparation and checkout is then mounted on heavy-gage railroad tracks and it is pulled back away from the missile at the time of launch.

Mr. DUCANDER. Where is the new one going to be?

General OSTRANDER. If you look on page 415–7, at this plat plan in the far left-hand side of your page at the north end of the cape, you notice listed there Saturn I launch area.

Mr. MILLER. Saturn I and Saturn II.

Mr. DUCANDER. Oh, yes.

General OSTRANDER. Saturn I is the one which is currently under construction and for which we are requesting the additional funds for completion.

Saturn II is farther north and we have to place it this way because, again, as at Huntsville, we could not use a single blockhouse for two launch pads as has been done in the past because of the blast dangers.

The blast of this missile of this booster is equivalent to something, I think, in the neighborhood of 75,000 pounds of TNT and safety distance criteria are the reason for the separation of the second launch complex from the first.

Mr. MILLER. This one is almost getting pretty far north in Cape Canaveral?

General OSTRANDER. Yes, sir, this is about as far as you can go. I think the actual end of the Government land is just about at the end of your picture here.

Mr. MILLER. Off the record.

(Discussion off the record.)

Mr. MILLER. Judge, you are here just in time. We have been through the matter of completing or changing the one Saturn stand. Now, this is a completely new stand for the Saturn. It is well documented.

Mr. CHENOWETH. What page is it on?

Mr. MILLER. Well, you can start at 415–6. There are a number of pictures. There follows the same reasoning—this is a completely new facility; an alternate facility. You have one, but stepping up the program, and the number of months that these things have to be in use—it is a complete new facility, so you have two; if you lose one you still have one to go.

Mr. CHENOWETH. This is at Canaveral just for testing?

Mr. MILLER. No, this is the launch pad.

Mr. CHENOWETH. This is the one that does the business.

Mr. MILLER. Yes, sir.

Mr. CHENOWETH. Do you have any there now?

General OSTRANDER. We have one under construction.

Mr. CHENOWETH. Not like Vandenberg, where you have got one ready to go?

General OSTRANDER. No, sir.

Mr. CHENOWETH. You are not that well along?

General OSTRANDER. No, sir.

Mr. MILLER. Of course, at Vandenberg, there are deployed weapons.

Mr. CHENOWETH. They have one ready to go there.

Mr. MILLER. That is right. This is for the moon probe.

Mr. CHENOWETH. No, I mean for some military significance.

General OSTRANDER. This has no connection with the military program.

Mr. MILLER. This is the space program—the moon.

General OSTRANDER. The space program. The one under construction at Cape Canaveral at the present will meet the schedule of our first launching, which is in calendar year 1961.

Mr. CHENOWETH. First launching of the Saturn.

General OSTRANDER. Yes, sir.

Mr. MILLER. I don't think the judge was here when you gave us this stepped-up program that the President has announced and has sent money down for.

General OSTRANDER. Under the expedited program which has been proposed to Congress by the President and for which he has requested $113 million, we step up our availability of an operational Saturn by about 1 year.

In other words, in calendar year 1962, instead of launching two Saturns, we would launch three. In 1963, instead of launching three, we will launch five. In calendar 1964, instead of launching four, we will launch six.

This is a general idea of the expedited program.

Mr. CHENOWETH. When is the first one?

General OSTRANDER. First one 1961—about the middle of the calendar year.

Mr. MILLER. It takes nearly 2 years to build this stand. And by the time you get into this 1963 program, how long do you say these are on the stand—about 4 months?

General OSTRANDER. About 3 to 4 months, as I remember, is the present period.

Mr. MILLER. So that to get them off, you have to have two stands, and you have two stands against the contingency that something may happen.

Mr. CHENOWETH. You are talking about an operational Saturn?

General OSTRANDER. I am talking about the development testing of the Saturn.

Mr. CHENOWETH. Still on the testing?

General OSTRANDER. Yes, sir.

Mr. CHENOWETH. When do you expect the first operational one?

General OSTRANDER. Under the present plans, about the second quarter of 1964.

Mr. CHENOWETH. Is there any chance to step that up a little?

General OSTRANDER. I think not.

Mr. MILLER. We are going pretty fast now.

General OSTRANDER. I think, with the additional funds which the President has requested, we are stepping the program up to the maximum that we can and still retain a reasonable, well-organized program.

In other words, anything beyond this would be a crash program into which we would have to throw in additional funds which perhaps could not be used as wisely.

Mr. CHENOWETH. If you are going to launch your first Saturn next year, why would you have to wait 3 years to put it in operation?

General OSTRANDER. The program consists of three launches with only the first stage. The two upper stages would consist of dummy stages, simply to provide the weight and the structure.

The second three launches would consist of the first two stages with a dummy third stage, then approximately four launches of the

complete three-stage bird to check them all out together and at that point we would consider it operational.

Now, this is an awfully hard line to draw, because it depends entirely upon our success during the development program. It is conceivable that with good luck, we might have what we consider an operational bird prior to this time.

Mr. CHENOWETH. What are you going to do in 1961, what are you going to launch?

General OSTRANDER. We will launch one and this will consist of the first stage, 1,500,000 pound thrust.

Mr. MILLER. This is the big thrust.

Mr. CHENOWETH. That is all you are going to do is just test the thrust.

Mr. MILLER. That is all in 1961; yes, sir.

General OSTRANDER. Right.

Mr. CHENOWETH. What is the next step?

General OSTRANDER. The next step, we will have three of these launches, the next step will consist of the first stage with the 1,500,000-pound thrust and the second stage with the hydrogen-oxygen engine and with a dummy third stage.

Then from there we go to a configuration where we have all three of the stages operating together.

Mr. CHENOWETH. If your 1,500,000-pound thrust is successful, haven't you then accomplished your main objective in the Saturn? The other thing—which is the most important, the thrust or what follows there? Where do you think you are going to have the most difficulty?

General OSTRANDER. You have to have all of them in order to do the job that we need to do with Saturn. In other words, in order to carry the payloads which are required by the Saturn program, you must have developed all three of these stages. There are certain interim jobs which we could conceivably do and probably will do in connection with the testing of the two-stage version.

However, to do the jobs in our program we need all three stages.

Mr. CHENOWETH. Couldn't the three stages be going forward simultaneously?

General OSTRANDER. Yes, sir.

Mr. MILLER. They are going forward simultaneously?

General OSTRANDER. However, the first stage as you know, was initiated in 1958, and is well underway. We now have asked for proposals from industry for construction of the second stage and very shortly we will do the same on the third stage.

Mr. CHENOWETH. Will different people be working on the different stages?

General OSTRANDER. Yes, sir.

Mr. CHENOWETH. I can't see why you are going to have to wait until 1964, then. It seems like an awful long time.

Mr. MILLER. I think, Judge, this is a very big job.

We should have tackled it maybe years ago.

General OSTRANDER. To begin with, sir, we are, in the upper two stages, using hydrogen and oxygen propellants. This is a relatively new technology, although we have had very good success to date in accumulating over an hour of running time on an engine burning

hydrogen and oxygen. This, incidentally, may not sound like very much, until you consider that the engines will only operate only a few minutes in actual flight.

In addition, we have to incorporate this engine into a complete upper stage. We have to design in the guidance, we have to learn to mate the stages together and work out the alinement problems. Each stage must be tested individually and all must be assembled before we have a complete vehicle. It is a program which is highly sophisticated, highly complex, and it simply takes us this amount of time.

Mr. CHENOWETH. Is work going forward now on all three stages?

General OSTRANDER. Work is currently underway on all three stages. By that, I mean the first stage is currently under construction, and nearly ready for test at Huntsville. We have gone to industry for bids on the second stage and in the very near future we will go to industry on bids for the third stage.

Mr. CHENOWETH. Who is doing the first stage?

General OSTRANDER. Huntsville, themselves.

Mr. CHENOWETH. They are doing that?

General OSTRANDER. Dr. Von Braun.

Mr. CHENOWETH. But the other two will be contracted out?

General OSTRANDER. The other two will be contracted out.

Mr. MILLER. Now, don't talk about——

Mr. CHENOWETH. We have some excellent sites in Colorado to do this work.

Colonel HEATON. I think it is wise to emphasize strongly the importance of having backup launch facilities because of the time which would actually be lost should we have a catastrophic explosion. We have had some experience, of course, in Cape Canaveral already with some of those explosions and the time required to repair a badly damaged facility. At least 9 months' delay could easily occur in a very bad explosion.

In gaging the importance of a second launch facility one should consider that each of these vehicles costs in the same order of magnitude as the complete launch facility we are talking about and a 9-month delay means about $80 to $100 million worth of lost time in terms of just the missiles alone.

Mr. MILLER. That is the very thing we are fighting for right now, 1 year, and we could easily wipe out the entire gain if you had one loss.

Colonel HEATON. Yes, sir.

Mr. MILLER. And you would still have to go back and spend this much money putting the pad into operation.

Colonel HEATON. Yes, sir.

Mr. CHENOWETH. What does one of these pads cost?

Mr. MILLER. $21 million.

Mr. CHENOWETH. You say that could be wiped out?

Colonel HEATON. Not the whole amount would be, but the time involved is what I am talking about.

Mr. MILLER. It would take 9 months to rebuild it.

Colonel HEATON. To rebuild the damaged portions and get it back in a serviceable condition.

Mr. CHENOWETH. Has that been your experience at Canaveral?

Colonel HEATON. Yes, sir. We had an explosion which was fairly severe on pad No. 12, and I don't recall the exact number of months

for getting that one back into shape, but it was an extensive period of time, and this was a much smaller vehicle than Saturn.

Mr. MILLER. How many pads do you have there now?

Colonel HEATON. There are four at the present time.

Mr. MILLER. So that you have duplicate pads for all of the other units?

Colonel HEATON. Yes, sir; many more than that. The same applies to the Titan program.

Mr. MILLER. You have how many Titan pads?

Colonel HEATON. Four of those.

Mr. MILLER. You are only asking for two of these?

Colonel HEATON. That is right, sir.

Mr. HECHLER. I just want to underline in addition to the 20 million that you mentioned, the 8 million.

General OSTRANDER. Yes, sir. What we are attempting to do here within the limits of our funding is to build those items which are long leadtime and which we would most badly need in case of this catastrophic explosion. Some of the additional short leadtime instrumentation items and some of the supporting facilities, such as the hydrogen storage, the liquid oxygen storage and the subsidiary activities surrounding the launch pad will have to be funded in 1962.

Mr. HECHLER. How high a vehicle can this test facility take?

General OSTRANDER. This particular one will take the C–1 which would be probably in the order of 160 feet, thereabouts. The foundations and the structure is built so that it can be extended for the later, larger versions, just as the Dynamic test facility was at Huntsville.

Mr. HECHLER. You are fully satisfied, then, that the current plans for construction could take care of the new Saturns?

General OSTRANDER. Yes, sir; it is designed for that purpose.

Mr. HECHLER. I wonder if you could state for that inquisitive institution known as the "record", just how you would define with reference to Saturn, "operational"?

General OSTRANDER. This, as I mentioned to Mr. Miller a moment ago, is an awfully hard line to define precisely. It is the point at which we are fully confident that all elements of the system are sufficiently reliable so that we are willing to risk very expensive and very important payloads because of a high degree of probability of success.

Mr. HECHLER. How high a vehicle can you service at the second Saturn launching complex?

General OSTRANDER. The current structure—you mean in terms of height on the pad, sir?

Mr. HECHLER. Yes.

General OSTRANDER. The current structure that I remember is about 205 feet. I don't know whether I have that figure here or not.

Colonel HEATON. They use the term 30-story building.

Mr. HECHLER. Yes, I see that.

General OSTRANDER. I believe the figure is 205 feet clear space, with potential for adding, I believe it is, two more of these sections that you see on page 415–10, to the top of the servicing structure to accommodate any larger versions of the Saturn.

Mr. HECHLER. Have you thought about hurricanes?

General OSTRANDER. Yes, sir. This is designed to withstand the hurricane loads that are expected in the Florida area.

Mr. HECHLER. As in Colorado, we don't have hurricanes in West Virginia.

Mr. CHENOWETH. That is right.

Mr. MILLER. Or in California.

General OSTRANDER. We put a great deal of time into the design for just this purpose. This ties in with our requirements for protection against blast in event of an explosion.

Mr. CHENOWETH. Off the record.

(Discussion off the record.)

Mr. CHENOWETH. Saturn is being designed for the big shots?

General OSTRANDER. Yes, sir.

Mr. CHENOWETH. It has no military significance?

General OSTRANDER. Not at this point, sir. It is conceivable that the military may establish requirements, but at present, it is being primarily designed for our civilian space exploration program.

Mr. MILLER. Civilian space exploration. We want to put up these weather stations.

Mr. CHENOWETH. We seek to recover some of the lost prestige occasioned by the first sputnik? Is it to appease our vanity here?

General OSTRANDER. One of the primary programs the Saturn would be pointed at would be manned lunar exploration. In other words, the possibility of putting man actually in orbit around the moon and returning him to the earth.

And in addition, the so-called soft landings on the moon where we can land approximately 9,000 pounds of scientific equipment which would set up either a stationary or a mobile exploration station on the moon to determine some of the composition and characteristics of the moon.

Mr. CHENOWETH. These are really for the big shots, then?

General OSTRANDER. Yes, sir; these are tremendously large payloads.

Mr. CHENOWETH. Of course, we come back to the original question now, the controversy has never been fully settled as to whether we should put more emphasis on the military or on the civilian development of space.

Mr. MILLER. It is a good deal like developing the airplane or the motortruck. It had its impetus in World War I.

Mr. CHENOWETH. General Medaris was very critical yesterday, dividing our shots too thin.

Mr. MILLER. He was that, but he was also very emphatic about the fact that we should get on with the Saturn; most emphatic.

General OSTRANDER. I might point out in this particular area of our program, that is the area of launch vehicles or boosters, we have had and expect to continue to have a very close and a very good relationship between NASA and the Department of Defense.

We have formulated jointly the national launch vehicle program. We have a number of projects which we are either using or developing jointly. I work constantly with people in the Department of Defense on making sure that we both use the same type of vehicle.

I think there is good coordination.

Mr. CHENOWETH. Now, we are engaged in Saturn, it is not in any way interfering or retarding what we are doing with Atlas or Titan?

General OSTRANDER. Not in the least.

Mr. MILLER. Contributing to them.

Mr. CHENOWETH. The argument is being made here that we ought to get more Atlases built and operational, get Titan ready for operation, which I understand is next year. Every day that is the No. 1 question here in Washington, just where we are and what we are doing, how far the Russians are ahead and when we are going to catch up, when we are going to fill the gap.

Mr. MILLER. This is helping to fill the gap, close it.

General OSTRANDER. I can see no possibility of the Saturn program impinging upon or slowing up the ICBM programs.

Mr. CHENOWETH. Except to the extent that the energies being pushed into Saturn could be devoted to something else.

General OSTRANDER. True, but to date, I don't think that lack of either industrial or engineering capability has been the limiting point on our programs.

Mr. CHENOWETH. The Saturn is going to be the No. 1 project for the Von Braun team?

General OSTRANDER. Yes, sir.

Mr. CHENOWETH. That is the No. 1?

General OSTRANDER. Yes, sir; highest priority.

Mr. CHENOWETH. Exclusively, they will be doing nothing else.

General OSTRANDER. No, sir, he will be engaged in other programs, but this is his high priority program and by far, his largest program.

Mr. CHENOWETH. I see. What else will he be doing down there?

General OSTRANDER. He will be handling for us the so-called Atlas Agena B, and also the Atlas-Centaur program. He will be engaged for the time being under terms of agreements with the Army in finishing up some of the programs which he was doing for the Army, the Jupiter, and the Pershing missiles.

He is winding up a certain number of Juno–2 shots for NASA which he has taken on even prior to the time he was slated to become a part of the NASA organization. What else?

Colonel HEATON. I think there are a few Redstones left for the Mercury program.

General OSTRANDER. Yes, sir. I believe that pretty well covers it.

Mr. CHENOWETH. He is going to be pretty busy down there.

General OSTRANDER. Yes, sir.

Mr. MILLER. Anything more?

Mr. CHENOWETH. No.

Mr. DUCANDER. No.

Mr. HECHLER. No.

Mr. MILLER. Well, that finishes up Huntsville and we can't very well finish this other thing today.

Mr. HECHLER. Atlantic Missile Range——

General OSTRANDER. The rest of the items at Cape Canaveral are simply sub——

Mr. MILLER. Doesn't that finish it in the book there?

General OSTRANDER. There are two more items. One is a staging building.

Mr. MILLER. Excuse me. That is under the Atlantic Missile Range—no, it isn't, it is Canaveral.

General OSTRANDER. This is simply a building where we bring in and assemble and handle and mate these various Saturn stages before we erect them.

Mr. MILLER. This is just a building, nothing tricky about that.

General OSTRANDER. No, sir.

Mr. MILLER. If there is no objection, we will go over——

Mr. DUCANDER. Nothing tricky about this. [Laughter.]

Mr. MILLER. This building, I assume, has to be quite comparable to the new building we authorized down at Huntsville, too, to handle this Saturn?

General OSTRANDER. Yes, sir.

Mr. MILLER. And an addition to the engineering and laboratory building.

General OSTRANDER. This is as a direct result of the step-up of our Saturn launch schedule at Canaveral. As you know, the policy in the past is that the users of the facilities at Cape Canaveral are responsible for funding their own construction down there. This is simply an extension of our existing engineering and laboratory space for the missile launch laboratory, who will do the launchings of the Saturn at Canaveral.

Mr. MILLER. If there is no objection, we will consider that.

Now, the next one is the various tracking facilities.

Mr. DUCANDER. Mr. Chairman, is this a good point?

Mr. MILLER. I think this would be a good place to break right now. You will try to have an Army man here Monday morning?

Mr. DUCANDER. Yes, sir.

Mr. MILLER. We can use this same room.

Mr. DUCANDER. Yes, sir.

Mr. GLEASON. When do we come back? This afternoon?

Mr. DUCANDER. No, Monday morning at 10 o'clock.

Mr. MILLER. All right. We will adjourn until Monday morning at 10 o'clock.

(Whereupon, at 11:56 a.m., the subcommittee adjourned to reconvene at 10 a.m., Monday, February 22, 1960.)

1961 NASA AUTHORIZATION

MONDAY, FEBRUARY 22, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE No. 1,
Washington, D.C.

The subcommittee met at 10 a.m., in room 304, Old House Office Building, Hon. George P. Miller, chairman of the subcommittee, presiding.

Mr. MILLER. The meeting will come to order.

Mr. DUCANDER. General Barclay is here.

Mr. MILLER. General, we are very happy to welcome you here. We wanted someone to clear up a few points with respect to NASA's request for some money to be spent at Huntsville. We made the request to the Pentagon, Judge Chenoweth, so they sent the General from Huntsville. We are happy to see him here, but we don't like to take up all of your time coming up here.

General BARCLAY. That is quite all right, sir.

Mr. DUCANDER. The items start on page 380, Mr. Chairman.

Mr. MILLER. 380.

General, the question that came up with respect to Huntsville is this: The Von Braun team is transferred to NASA. The Von Braun team has been operating at Huntsville.

Immediately after its transfer, NASA asks for $27, 500,000, I think it is, for certain capital improvements at Huntsville. This is a question that may be raised on the floor: Why is it necessary, in the transfer administratively of this team, to immediately go in and spend this amount of money at Huntsville? Where are the facilities that the Von Braun team used at Huntsville? Why aren't they available? Why can't the Army turn these over?

Is it a question that the Army, now that the Von Braun team is no longer their responsibility, is taking the position: Well, you have to supply your own facilities?

I merely cite these. I think I know the answer but we do want to get into the record some answers to those questions so that we will be prepared to defend them on the floor.

General BARCLAY. Yes, sir.

Mr. MILLER. So we are very anxious to come to the Army for them.

Now I understand that in the original budget of the Army for this year there would have been some $13 million or more for some of these facilities at Huntsville, had the Von Braun team not been transferred.

If that is correct we would like you to bring that out, too, so that we will have the positive information and data on which to rest our case if this question is raised.

General BARCLAY. Yes, sir.

Mr. MILLER. And I think it will be raised. Will you proceed now, sir?

STATEMENT OF BRIG. GEN. JOHN A. BARCLAY, COMMANDER, ABMA, AND DEPUTY COMMANDING GENERAL, ARMY ORDNANCE MISSILE COMMAND, REDSTONE ARSENAL, ALA.; ACCOMPANIED BY MAJ. LEONARD S. FRANKENSTEIN; LT. COL. ROBIN ELLIOTT, WAC; AND LT. CONRAD C. EGE

General BARCLAY. The Army has submitted four plans for the Saturn program. The first three were submitted to the Advanced Research Projects Agency, ARPA, under whose jurisdiction the Saturn program has been, up until its recent transfer to NASA.

The first of those programs was submitted in February of 1959. That plan contemplated a total of $20.5 million in facilities for the fiscal years 1960 and 1961.

A revision of that plan for a total program of $130 million was submitted in July of 1959, and that proposal included facility requirements of $8.9 million.

An accelerated program, submitted at the same time, for a total program cost of $250 million, contemplated facility requirements for fiscal year 1961 of $35.2 million.

Mr. MILLER. These are at Huntsville?

General BARCLAY. These are at Huntsville and at Cape Canaveral, both. These are the facilities requirements which would be needed to carry forward the program as planned at that time.

In December, the last plan submitted to ARPA contemplated the $13 million in facilities. That is the $13 million to which I believe you have reference.

As recently as January of this year, a proposal to ARPA for the present program of $230 million total program contemplated $46.5 million of facilities.

Mr. MILLER. At both Canaveral and Huntsville?

General BARCLAY. At both Huntsville and Cape Canaveral.

Reviewing these facilities by specific item, I find that, with the exception of those which had been introduced by reason of the change in technical direction of the Saturn program, that is the change from a liquid oxygen-kerosene type upper stage to a liquid hydrogen-oxygen upper stage, all of these facilities were contemplated in the programs previously submitted by the Army.

There have been some modifications. For example, NASA now is asking for an administrative and central laboratory building. The Army had previously, in its military construction program, placed a requirement for an aeroballistics laboratory. NASA's plan, as I understand it, is to expand that laboratory and include office space in it.

If you would like, I can summarize these items in detail.

Mr. MILLER. I wish that you would, sir.

General BARCLAY. All right, sir.

Under the static test facility at Huntsville, the Army plan contemplated two possible approaches to that. One of $7 million, and

under the maximum accelerated program $12.4 million. The current NASA request is $10.8 million.

The central laboratory and office facility——

Mr. CHENOWETH. Before you leave that, first, would you tell us just what is involved in that test facility?

General BARCLAY. Yes, sir.

You are familiar, I believe, Mr. Congressman, with our test stand at Huntsville——

Mr. CHENOWETH. Yes, we saw that.

General BARCLAY. Which we now have. Under the accelerated program it would be necessary to have two Saturn missiles on the stand at one time in order to check them out and go through the static firing and the vibration testing. We cannot with our present facility have two Saturns on that one stand.

Mr. CHENOWETH. You have to build an entirely new facility.

General BARCLAY. We would have to build an entirely new facility, which does not embrace all of the current facilities, but would embrace the tower and the instrumentation and the blockhouse and those facilities which are necessary for a static firing.

Mr. CHENOWETH. You would use part of the old facilities?

General BARCLAY. Yes, sir; we would continue to use them and expand the capacity by building a second tower.

Mr. MILLER. But when you have to build the second tower you have to have the new instrumentation.

Mr. CHENOWETH. Would you enlarge the old tower?

General BARCLAY. That is already enlarged. It is enlarged, and as of Saturday we placed the first Saturn booster on the tower. The new facility would be essentially a duplicate of that, built primarily for Saturn.

Mr. CHENOWETH. It will take $10 million for that?

General BARCLAY. Yes, sir; that is correct, $10.8 million for the tower, blockhouse, instrumentation.

Mr. CHENOWETH. That is a permanent installation?

General BARCLAY. That would be a permanent installation, yes.

Mr. DUCANDER. And you understand the expedited program was going to ask for $12 million for this same facility?

General BARCLAY. Yes, that is correct. The Army plan for the expedited program asked for $12.4 million.

Mr. MILLER. NASA asks for $10?

General BARCLAY. Asks for $10.8.

The items that were eliminated from that, I don't have here. If you are interested, I could obtain them for you if you want them.

Mr. DUCANDER. I was just interested in the comparison, that is all.

Mr. MILLER. Just the comparison. That was this $10.8 where the Army was going to ask for $12.4.

General BARCLAY. $12.4 million.

Mr. MILLER. All right, sir. Thank you on that one.

General BARCLAY. The next item is the "central laboratory and office facility." Under the Army military construction program, the Army Ballistic Missile Agency had filed a requirement for an aeroballistic laboratory at a cost of $2 million. Under the NASA plan they are asking for $4.4 million which will be a consolidation, a central laboratory and office facility.

Mr. MILLER. Now the present office facilities that the Army has down there are pretty well bursting at the seams, aren't they?

General BARCLAY. Yes, sir; they are crowded at the moment.

Mr. MILLER. So that is why you were going to request this anyway?

General BARCLAY. That is correct.

Mr. MILLER. And will the fact that the Von Braun team is now going over to NASA, and when we build this building will it mean that there will be a lot of surplus office space in your administration building?

General BARCLAY. No, sir.

Mr. MILLER. The Army will use all of the facilities, you need them now?

General BARCLAY. That is correct. In fact, the Army will not only need all of that office space but the Army will need some $12 million in facilities to replace the laboratories which are being transferred to NASA.

Mr. MILLER. To NASA?

General BARCLAY. The Army plans to recreate its missile supervision capability on a much smaller scale than has existed in the past, because we still have our weapons system for which we are responsible, and we will need to see that those are carried forward.

Mr. MILLER. And if there is a stepup in Nike-Hercules you will have to do some of that work.

General BARCLAY. That is correct; yes, sir. The Nike-Hercules remains with the Army, the Pershing missile, the Sergeant, and all of our current missile programs.

Mr. MILLER. All your tactical missiles are still there and you still have a requirement for those and the facilities for them at Huntsville.

General BARCLAY. That is correct; yes, sir.

Mr. DUCANDER. Mr. Chairman.

If the Army had retained the Saturn project, did your advanced planning contemplate additional employees?

General BARCLAY. We did not plan additional Government employees. We planned to utilize additional contractor people.

Mr. DUCANDER. If you had additional contractor people, how would they be taken care of as far as office space is concerned?

General BARCLAY. We have one building, which was built as a contractor-engineering support facility. It is a building situated in the rear of our headquarters, not physically connected with the building. That is primarily used for contractors' people who are resident at the arsenal assisting in these programs.

Our philosophy with respect to our personnel strength has been that we did not want to build up to a peak beyond that which we could sustain; and that our best approach was to utilize contractors, maintaining our civil service strength at that which we felt we could maintain for the long pull.

Mr. MILLER. Inasmuch as the stepped-up program would require additional personnel, you would have had to provide facilities for these additional personnel?

General BARCLAY. That is correct.

Mr. MILLER. Whether civil service employees or contractors' employees?

General BARCLAY. Yes, sir.

Mr. MILLER. All right, General.

General BARCLAY. The next item is the dynamic test facility, which the Army had in the program at $600,000, and the NASA requirement is the same, total $600,000.

Mr. MILLER. Same. That is from pages 289 to 303.

General BARCLAY. The pressure test cell, the Army asked for $650,000 and the NASA has asked for the same total of funds.

The extension of the assembly building to join buildings 4705 and 4706, the Army had asked for $2½ million; NASA has asked for the same total.

The addition to the engineering building, No. 4610, was in the Army military construction program at $1.395; NASA's fund requested is $1.137.

Mr. DUCANDER. You asked for $395,000?

General BARCLAY. $1,395,000, and NASA's figure is slightly less, $1,137,000.

The completion of the third wing of the guidance and control laboratory was in the Army military construction program at $1.948 million; NASA has asked for the same funds.

The addition of ——

Mr. MILLER. That is on page 408.

I am giving those pages so we will get them in the record, so we can refer to them.

General BARCLAY. I am sorry, I don't have a cross-reference.

The addition to the fabrication laboratory was in the Army MCA program, minor construction, for $190,000, the NASA request is $215,000.

Mr. MILLER. That is on page 411.

General BARCLAY. The addition to the checkout building was in the Army plan for $3.5 million; NASA has asked for $4.5 under the present Saturn.

Mr. MILLER. Page 411.3.

General BARCLAY. That increase in funding is primarily due to the greater safety requirements by use of hydrogen rather than kerosene.

Mr. MILLER. Mr. Chenoweth, have you any questions?

Mr. CHENOWETH. General, I get the impression that the switch, then, from Army to NASA hasn't entailed too much additional expense so far as these facilities are concerned; is that a correct observation?

General BARCLAY. That is correct, sir. That is right. Most of these facilities would have been required for the Saturn program regardless of who executed the program.

Mr. CHENOWETH. The Army had its own plans for some or most of these, according to what you tell the committee now.

General BARCLAY. Yes, that is right.

Mr. CHENOWETH. So you would say there has been very little increase——

General BARCLAY. Very little, that is correct.

Mr. CHENOWETH. In the amount which is going to be spent?

General BARCLAY. Yes.

Mr. CHENOWETH. Some changes are up a little here, and down a little there.

General BARCLAY. Most of which have resulted from the changed technical approach in the program or further study which may have shown——

Mr. MILLER. Technical and stepping up the program.

General BARCLAY. And increasing, that is correct.

Mr. MILLER. Which would mean——

General BARCLAY. The additional stand, for example, would not be needed if they were on the early slow firing schedule.

Mr. MILLER. But if we are going to step up and cut out this one year—how long do you have to keep them on the stand?

General BARCLAY. We will keep these missiles as much as 2 months on the stand. And we are firing in 1963, NASA is, as many as two missiles in a quarter. So to maintain that pace, it is essential to have two stands, and you will have to take your choice of accelerating the program and providing facilities to do it, or taking the more leisurely schedule.

Mr. MILLER. That is right. And that is another reason for this new pad at Canaveral which you are asking for?

General BARCLAY. Yes.

Mr. MILLER. And had the Army been in charge of this program and it had been stepped up as it is now under NASA, you would have had to have that new pad?

General BARCLAY. We would have required these same facilities.

Mr. MILLER. Same facilities.

General BARCLAY. And had already registered that requirement with ARPA for the accelerated program.

Mr. CHENOWETH. Do you expect much confusion, difficulty, or inconvenience, in making this shift-over at Huntsville?

General BARCLAY. Sir, there will be some disruption. We are planning as well as we are able, and hope to keep it to a minimum. I think the disruption will not be noticeable outside of our own organization.

Mr. MILLER. The relationship between the Army and NASA has always been good.

General BARCLAY. It has been very good.

Mr. MILLER. Congenial cooperative spirit.

General BARCLAY. Yes, sir.

Mr. MILLER. Of course, this is an infusion of Army blood into NASA.

General BARCLAY. Yes, sir.

Mr. MILLER. It will help leaven out——

General BARCLAY. I think the result will be salutary.

Mr. MILLER. I think it is a very good plan, myself.

General BARCLAY. We have had excellent working relationships with the NASA group. We are planning the transfer carefully and not taking any steps precipitously, in order that we can assure that the program continues, first of all, and that there is the least disruption to the operations, and as little as possible derangement of the morale of our people.

Mr. CHENOWETH. So far as the Von Braun team is concerned, they will remain intact? Will there be any change in their schedule or program or daily activities there? How will it affect them?

General BARCLAY. They will remain as a group working as they are in the same locations.

Mr. CHENOWETH. In other words ——

General BARCLAY. Ninety-eight percent of the people probably will not know the difference.

Mr. MILLER. They will get a different-colored check.

General BARCLAY. Yes, sir. But the dollars they get for that check are still green and still come from the U.S. Treasury.

Mr. MILLER. Same.

Mr. CHENOWETH. This is off the record.

(Discussion off the record.)

Mr. MILLER. On the record.

Mr. DUCANDER. General Barclay, now the Army has been handling all of the contracting, the legal work, and that type of administrative work for the Saturn project. Now, NASA, after July 1st, will start doing that. Will this mean a decrease in the number of Army personnel that have been doing that type of work for the Saturn project at Huntsville?

General BARCLAY. Yes. There will be some 35 people who have primarily been handling the contractual arrangements at Huntsville who will go to the NASA organization to assume this responsibility for NASA.

The actual contracting, of course, has been done through the Ordnance district offices. A number of people in the various offices have been engaged in this area. They will continue to do this for NASA until such time as NASA creates their own procurement capability.

Mr. DUCANDER. Then will there be a decrease in Army personnel at Huntsville?

General BARCLAY. Yes. Yes, there will.

Mr. DUCANDER. So as we—I say "we"—as NASA increases its personnel to take care of these administrative matters that the Army has been handling, increases their own personnel, then the Army personnel will in turn decrease?

General BARCLAY. They will decrease. That is correct. There are some 815 people that are currently with the Army in administrative support areas who will be transferred to NASA and will carry on the operation for NASA and be dropped from the Army rolls. For example, in our supply operations at ABMA the entire staff operating the warehouse and keeping the supply records will be transferred to NASA, with the supplies.

A segment of our personnel office will be transferred; a segment of our procurement office; a group of the plant maintenance people will be transferred to NASA; a cadre from the civilian personnel office and safety and security; and all those functions will be cadred to NASA.

Mr. CHENOWETH. Are those military or civilians?

General BARCLAY. Primarily civilians.

Mr. CHENOWETH. Civilians.

General BARCLAY. Yes, sir.

Mr. CHENOWETH. What will the impact be on the military strength?

General BARCLAY. The military strength will not decrease. They are primarily working on the weapons systems.

The exception to that is in our scientific and professional enlisted personnel, our technically trained college graduates who have been drafted and are assigned there. Some of those people will remain with Von Braun's group and work for NASA until such time as their enlistment expires, and then they will be phased out.

Mr. MILLER. How about in the future? You have been picking these people up throughout the Army.

General BARCLAY. We will continue to do that and give them this training and work, on the Army's missile systems.

Mr. MILLER. On the Army systems?

General BARCLAY. Yes, sir.

Mr. MILLER. Will any of those be available to NASA while still in uniform on a reimbursable basis perhaps?

General BARCLAY. We do not have such a plan at the moment.

Mr. MILLER. But it is possible?

General BARCLAY. It is possible, yes, sir.

I have discussed it with Dr. Von Braun and General Ostrander; NASA is interested, if we can work out arrangements whereby that can be done.

Mr. MILLER. I think this is a good source of manpower.

General BARCLAY. It is excellent.

Mr. MILLER. It has worked out that way, I understand it.

General BARCLAY. Yes, sir.

Mr. MILLER. I just assume that NASA will be as much interested——

General BARCLAY. These engineers are a very fine asset to the Army. They have come there and integrated themselves, and many of them remain with the Von Braun team as technical personnel after their enlistments expire.

Mr. CHENOWETH. I had the impression a number of the military had made a special request to stay with the team after NASA took over. They will want to stay in the program.

General BARCLAY. Yes, sir, they do. And most of the enlisted personnel who have been with our Development Operations Division and with Dr. Von Braun will remain with him. We do not plan to reassign them.

Mr. CHENOWETH. Will any of the military personnel be separated at all that have been in the program?

General BARCLAY. No, sir. All the military, except these scientific and professional enlisted people, are assigned in other areas than the Development Operations Division, or on Army weapons systems.

Mr. CHENOWETH. They will continue the work in which they are engaged now?

General BARCLAY. Yes, sir; they will continue on the same programs.

Mr. CHENOWETH. So it will have no impact at all on the military personnel.

General BARCLAY. No, sir; none whatsoever.

Mr. DUCANDER. Actually, Mr. Chairman, just making a mental addition of these expenses at Huntsville, it seems to me there is only about

$2 million going into the administration building for NASA which is over and above what the Army would have spent in the first place.

Mr. MILLER. That is about right.

Mr. DUCANDER. The Army was going to build an additional laboratory. Now NASA continues that, the laboratory, and adds to it some office space and that is going to cost in the neighborhood of $2 million. So that is about all the addition there is.

Mr. CHENOWETH. I think, Mr. Chairman, I want to commend you on bringing the general here, because I think this is going to be something that is going to come out on the floor: This great waste of money that is involved in shifting from Army to NASA.

Mr. MILLER. I want to be prepared for it. I hope it does not come there, but I think now we are well prepared to meet it.

Mr. CHENOWETH. Very good.

Mr. MILLER. I am very glad that the general could come up.

Mr. DUCANDER. Could you put your comparisons in the record?

General BARCLAY. Yes, sir. I will be glad to give you a copy. I did not tell you about the facilities at Cape Canaveral; however, they are essentially the same as the Army had planned. I can give you an itemized list.

Mr. DUCANDER. Just put the whole thing in the record. It would be most helpful.

(The information referred to is as follows:)

TABLE B.—*Fiscal year 1961 planned facility requirements for the Army Ballistic Missile Agency*

[Dollars in millions]

Requirements	Army planned requirements prior to proposed transfer of Development Operation Division to NASA					Total planned requirements subsequent to proposed transfer of Development Operation Division to NASA (remainder of ABMA to be reestablished as continuing Army agency)						
						NASA requirements presented by General Ostrander to congressional committee			Army requirements for reestablishment of ABMA			Grand total
	Nonaccelerated Saturn program of $130,000,000, total 1961, plan 2	Nonaccelerated Saturn program of $140,000,000, total 1961, plan 4	Accelerated Saturn program of $250,000,000, total 1961, plan 3	General (fiscal year 1961 MCA)	Total based on accelerated Saturn program	Saturn	General	Total	Saturn	General (fiscal year 1962 MCA)	Total	
A. Facilities at Huntsville, Ala	$7.337	$10.750	$20.154	$5.735	$25.889	$19.050	$7.700	$26.750	0	[1] $12.097	[1] $12.097	$38.847
1. Static test facility		[2] 7.000	12.417			10.800						
2. Central laboratory and office facility				[3] 2.000			4.400					
3. Dynamic test facility		.600				.600						
4. Pressure test cell		.650		.950		.650						
5. Extension of assembly building 4705-06	2.412	2.500	2.412			2.500						
6. Addition to engineering building 4610				1.395			1.137					
7. Completion of guidance and control building 4487				1.948			1.948					
8. Addition to fabrication laboratory				.190			.215					
9. Addition to checkout building	3.500		3.500			4.500						
10. Computation center				[4] 1.200						1.712		
11. Research and development facility											5.000	
12. Test evaluation and firing										1.500		
13. Motor pool										.085		
14. Industrial engineering building										1.900		
15. Systems maintenance equipment activities building										1.900		
16. Transportation facilities	.625		.625									
17. Miscellaneous minor facilities	.800		1.200									

B. Facilities at Cape Canaveral, Fla	1.607	2.250	15.067	.180	15.247	27.450	.300	27.750	0	0	0	27.750
1. Completion of 1st Saturn launch complex	1.607	2.250	1.607			2.250						
2. Escape mechanism for service structure						.300						
3. Hydrogen storage and handling facility						[4] 2.500						
4. Staging building						[4] 1.400						
5. Addition to engineering and laboratory building				.180			.300					
6. 2d Saturn launch complex			13.460			[5] 21.000						
C. Grand total	8.944	13.000	35.221	5.915	41.136	46.500	8.000	54.500	0	12.097	12.097	66.597

[1] Note that these requirements are now planned as fiscal year 1962 MCA, not fiscal year 1961.

[2] Based on incremental funding concept (not normally acceptable for facility construction).

[3] Included in fiscal year 1961 MCA as aeroballistics laboratory.

[4] Included in fiscal year 1961 MCA as additional wing for present computation laboratory.

[5] Increases due primarily to selection of liquid hydrogen-oxygen upper stages, launch area safety requirements, and provision for growth potential of upper stages. All of which are related to technical decisions on the scope of the Saturn program made by ARPA or NASA after submission of the last Army funding plan for Saturn.

Mr. MILLER. Thank you very much, General. Happy to see you here on George Washington's Birthday.

General BARCLAY. I hope we will have the pleasure of having you visit us again and we can crank up the big one for you.

Mr. MILLER. All right. We would like to go down. I have only been down to Huntsville once and I certainly enjoyed it on that occasion and I look forward to getting down there again.

Mr. DUCANDER. Before we break up, we have one item on the big book from NASA concerning the tracking facilities.

Mr. MILLER. Yes. We will go into that now and I think that that will just about clean us up.

This starts on page 419.

Major HAMMOND. 419, yes, sir.

Mr. MILLER. Sir, we are happy to see you here even on Washington's Birthday.

STATEMENT OF IRA H. ABBOTT, DIRECTOR, ADVANCED RESEARCH PROGRAM, NASA

Mr. ABBOTT. I am happy to be here even on George Washington's Birthday.

Mr. MILLER. Tracking facilities.

All right, Mr. Abbott, the tracking facilities. I believe there are three items involved in this whole phase. It starts on page 419.

Mr. CHENOWETH. What facilities is it?

Mr. MILLER. This is tracking facilities at various locations, and the first items of money come in on pages 424 and 425.

Will you, Mr. Abbott, tell us about these tracking facilities so that we will have something in the record?

Mr. ABBOTT. Yes, sir. I would like to have Major Hammond talk about these facilities. He is intimately familiar with all of them.

STATEMENT OF MAJ. VICTOR W. HAMMOND, USAF

Major HAMMOND. Good morning again, gentlemen.

Mr. MILLER. Happy to have you back.

Major HAMMOND. You will find we have four major line items in this total request for some $27,750,000. The Minitrack system plus some augmentation of that for special purposes which I will mention in a moment is $4,750,000, our deep space net is a total of $8 million, and the Mercury network is $15 million.

Now, to take these one at a time, beginning on page 424—incidentally, I will be more than happy to try to differentiate this from the classical Greek, if you like, as we go along.

Mr. MILLER. I think it would be well if you would define, first, the Minitrack net, what it does, then the augmentations, and then, again, the work planned for the $15 million that will be used for the Mercury phase of it.

Major HAMMOND. Yes, sir.

Mr. MILLER. I do not know whether the judge has had an opportunity but I read the four pages of this material.

Mr. CHENOWETH. I have not read it.

Mr. MILLER. Then we will get some of this into the record in that way.

Major HAMMOND. All right, sir.

To begin with the Minitrack network, let me say in preface here that when you speak of this type of equipment, the ground instrumentation, the tracking devices, and the telemetering and so on that collects data from these various vehicles, you must speak of four basic types of missions. First of all it is the vertical probe type of mission, that is the sounding rocket that we spoke of the other day regarding Wallops station.

Secondly, you have the earth satellite vehicle; thirdly, the deep space probe; and fourth, the special case of the earth satellite vehicle, namely the manned satellite which is quite different from the routine scientific satellite vehicle in that it orbits much closer to the earth's surface and, furthermore, it is only up on its mission for a total of some 4½ hours.

Now, the scientific satellite, on the other hand, orbits hundreds of miles high, to actually tens of thousands of miles high, and it is up for weeks and months and years. So you see the timeliness of collecting the data is quite a different thing. You actually have a long period of time to essentially boot-strap yourself by collecting just tiny bits of data periodically with the earth satellite, the scientific satellite class of vehicle. Then when you put all of these tiny bits of data together, with the aid of computers, of course, you can then mathematically describe the orbital characteristics or the path that the satellite is taking.

Now, for example on Vanguard II that flew last September it took the Minitrack network about 8 hours 50 minutes from the time of launch to a time when the orbital characteristics could be satisfactorily described mathematically.

Now, then, to visualize the manned satellite mission, attempting to use those same instruments it is quite unsatisfactory, you see.

Mr. MILLER. He will be up and down in half of that time.

Major HAMMOND. He is up and gone by that time; yes, sir. Therefore the Minitrack network, then, we can term sort of a workhorse system for the scientific satellite vehicle. It does three things for you. First of all it tells you where the vehicle is in space. It "tracks."

Secondly, it derives data—that is, the scientific data that is being collected by the instruments in the satellite—and brings it back and records it for future analysis on the part of the scientists.

And third, the Minitrack has equipment at each one of its stations that can give instructions back to the satellite, it can command various functions to occur in the satellite, turn on one device, turn another device off, things of this nature, you see.

Mr. MILLER. Gathering data as it goes along.

Major HAMMOND. Yes, sir. This whole field of instrumentation that I am speaking to now is the actual final payoff field in all of the various scientific efforts, the rockets, the deep space probes, and what have you. Without these type of instruments you simply cannot successfully get any type of data back from these explorations into space.

Mr. MILLER. If you do not have these and they are not refined—as refined as you can make them to get this information—there is no good in putting the vehicles up in the first place.

Major HAMMOND. Yes, sir; that is very true.

Mr. MILLER. Just for turning them around the world.

Major HAMMOND. Very true.

Mr. MILLER. You will get no data back. This is the only way you get it.

Major HAMMOND. This is the payoff, right.

Mr. MILLER. Now, to get these they have to be distributed at certain intervals and places completely around the globe.

Major HAMMOND. Yes, sir. This is a very good point. With the Minitrack network now you will find that it is distributed essentially along a line, the 75th meridian, so that as the satellite, on each path, passes through this line of stations, you see. That is why I said that you only derive seconds of data each time that the satellite makes a course around the earth.

Then by putting all of these bits of data together—because you have plenty of time to do this, you can construct the orbit, you see.

Mr. MILLER. This is a north-south line?

Major HAMMOND. This is a north to south line; yes, sir, right.

Mr. MILLER. That is why these stations then are substantially north and south of one another as you go around the world?

Major HAMMOND. Yes, sir. Now to differentiate between, again, the Minitrack and the Mercury equipment, you will find the Mercury equipment is deployed essentially on a great circle course around the earth. We could say beginning at Cape Canaveral and extending out to the island of Bermuda, a ship in the Atlantic, over to the Canary Islands, to Nigeria in Africa, Zanzibar on the other side of Africa, a ship in the Indian Ocean, Australia—two stations in Australia—and up over the Canton Island in the Pacific, up to Hawaii, west coast of the United States, Central United States, Eglin Air Force Base down in the Gulf of Mexico, and back down to Cape Canaveral. If you will look at this on a map you will see this is a great circle course right around the earth. These devices now in the Mercury network that provide this tracking function are radars. The reason they are radars and hence of course more expensive than the Minitrack equipment is because you must—well, you simply do not have the time available to boot-strap yourself with tiny bits of data, so you must collect as much data as possible per pass.

Mr. MILLER. This is where the thing takes place in about 4 hours.

Major HAMMOND. Exactly.

Mr. MILLER. So you have to get all of this information, of course, each time you put a man up or vehicle up. You have only 4 hours to get back the data that is necessary for the great investment that you have put in the vehicle and the great investment that you put in the man going up.

Major HAMMOND. Yes, sir. And one step further in this regard, Mr. Chairman, is simply that at launch of the Mercury mission, the orbital characteristics—that is, the path that the capsule is going to fly—must be determined immediately based upon the launch—the injection charactertistics, the velocity, direction, and magnitude at the point of injection into orbit, you see, because without this knowledge you do not know whether you are in the proper orbit or not. If you are not in the proper orbit, you want to immediately get that capsule

back out of orbit, back down to a recovery point where the capsule and its occupant can be picked up.

Mr. MILLER. That is right. This, when you stop to think of it, is a great responsibility on people's shoulders.

Major HAMMOND. It is, yes.

Mr. MILLER. If this thing gets out of orbit, if you do not get him back in, it will be disastrous.

Major HAMMOND. Right.

Now, to discuss the deep space net for just a moment, you will find that the deep space net consists of three stations. Now, these are deployed around the earth evenly—that is, at about 120° apart. One is in California at Goldstone near Camp Irwin.

Mr. MILLER. It is out on the desert.

Major HAMMOND. Yes, sir.

And the second one—incidentally, Goldstone is in operation now. The second station to go into operation—and that will be sometime this summer—will be at Woomera, Australia.

The third one to go into operation in the beginning of 1961 will be down in the Union of South Africa. Again, if you look at these locations on a map, you will find that they are about 120° apart around the earth. Now, what this means is that once the deep space probe proceeds on its flight to the moon or a planet you have continual coverage. You will have one of these stations in a position to be able to track this vehicle as it flies, regardless of the rotation of the earth, you see. Once it gets up about 10,000 miles high, then the coverage of these three stations are overlapping in nature, and when one—when the earth rotates one of them out from under the vehicle, the other one comes right up.

Now, we can speak specifically of these items here if you would like, sir.

Mr. MILLER. Well I think getting down to them, the first one is a building. This is the station development. The next one—I think the data acquisition antennas, tracking filters——

Mr. DUCANDER. Is this deep space net?

Major HAMMOND. No, sir, we are starting back on Minitrack.

Mr. MILLER. This is on page 424.

Major HAMMOND. Right.

Mr. MILLER. The command transmitters, high gain antennas, special equipment for meteorology and precision tracking. Portable electronic ranging and support equipment.

Major HAMMOND. May I speak to these, Mr. Chairman.

Mr. MILLER. Yes, if you will.

Major HAMMOND. I think it is quite interesting, actually. Although the major title here is the Minitrack net, this list of items encompasses more than the basic Minitrack network. It encompasses items that are to supplement the Minitrack capabilities.

Specifically, the items, command transmitters and modifications, calibration antennas, wide-band data acquisition equipment, high gain antennas and special equipment for meteorology and precision tracking—those three items are for prototype equipment that will be used to take the wide-band data, the very broad television type of data, from the meteorological satellite, the Nimbus program that you have probably heard of in the discussions thus far.

The next three items beginning with optical components, portable electronic ranging and support equipment, special equipment for calibration and timing—these three items are for five master geodetic stations. These are the type of stations now that will be able to derive very accurate position information from the geodetic satellite. The geodetic satellite can be compared to a bench mark in surveying. That is, we can call it a flying bench mark.

Now the tracking process of a missile, a rocket, a satellite, or what have you, is trying to establish where it is in space accurately.

Now, we will, with the Minitrack equipment, be able to know where the geodetic satellite is in space. However, now you must be able to go to various places in the world, around the earth—that is to say, for example, an island in the Pacific. You put this equipment on that island and then as that satellite flies overhead; you measure its position, and from that you can then derive the very accurate position of that island where your equipment was. In other words, this is an augmentation to maping, you see.

Mr. MILLER. This will give us a lot of very valuable data.

Major HAMMOND. Yes, sir.

Mr. MILLER. Heretofore, it has almost been impossible to get by celestial means—well you can do it by the stars, but you are never too sure of it, trying to fit triangles around the world.

Major HAMMOND. It gives you an excellent tie for, I would imagine, an approach to the first-order survey of essentially any spot on earth that you could take your ground equipment.

Mr. CHENOWETH. Does this work by contract? Electronic companies?

Major HAMMOND. The geodetic program is a combination with some of the other governmental agencies that are involved in map work, such as the Army Map Service, Coast and Geodetic Survey.

Mr. MILLER. I was going to say the Coast and Geodetic Survey would be very much interested in this.

Major HAMMOND. They are involved in the program; yes, sir. The actual items of equipment will undoubtedly be built by contractors; yes, by the electonics industry.

Mr. CHENOWETH. They will be operated by NASA, then.

Major HAMMOND. They will perhaps be operated by Coast and Geodetic Survey people, Army Map Service people. I am not too sure of the details of the program—geodetic satellite program.

Mr. MILLER. Some of these people are at Woomera. Will you not make deals with the Australian Government to operate this?

Major HAMMOND. Very definitely, yes, sir.

Mr. MILLER. You have a few people there to supervise it, but——

Major HAMMOND. Oh, by all means.

Mr. MILLER. Because this is a thing they are interested in, too. I believe that is the way you have done it.

Major HAMMOND. Yes, sir. With the stations that we have—and this is all stations—I was referring only to the geodetic stations just a moment ago, but with any station that is located in a foreign country—and you picked a very good one; namely Australia—we have agreements with these governments, with the aid of the State Department and so on, of course, that allow the use of citizens of that country to help in one degree or the other. In the case of Australia they

perhaps provide I am sure—there is perhaps only a representative from NASA there as a station manager. Other than that, all of the technicians and engineering personnel are citizens of that particular country.

Mr. MILLER. Major, this is entirely foreign to our discussion, but when I was reading this the other day it struck me that we have these, this is an augmentation, we have stations in these places now. Has Russia, do you know, stations throughout around the world? She certainly has none in the Western Hemisphere that we know of, does she?

Major HAMMOND. Well, this is——

Mr. MILLER. Or do we exchange data with them?

Major HAMMOND. We do exchange data through various agencies, for example COSPAR. During the International Geophysical Year period there were various international agencies set up to exchange data; yes, sir.

I would say, however——

Mr. MILLER. This is of course just scientific data, nonmilitary data.

Major HAMMOND. Yes, sir; that is right. We do have some knowledge and this is available in the open literature, of the Soviet instrumentation capability.

You have heard of the moon-watch teams, I am sure, here in this country that were set up under the IGY. These are essentially teams of volunteers who have rather simple optical devices. They are told by a central point—in the case of our moon-watch teams this is the Smithsonian Astrophysical Observatory—these teams are told where to look, for any given satellite, where to point their optical device and where to look and at what time to look, of course. They then make certain readings. They measure with respect to a star background where the satellite was and they send this information back to the Smithsonian for a general accumulation of data and entry into the computer.

This again is another tiny bit of data that helps bootstrap us into a position of knowing where the satellites are. The Soviets have a number of these deployed, of course, in their homeland. They also have optical devices that are comparable to our ballistic cameras, the Baker-Nunn type of camera, which is a specially designed device for tracking satellites.

We also know that they have certain electronic equipments. This also is available in the open literature.

I think, however, if your question is: Do we have as good devices as they have or the contrary? In other words, who is ahead in tracking? I think the answer to that is that the measure of tracking and the general field of instrumentation is a question of meeting one's requirements. Presumably they are meeting their own requirements.

Mr. MILLER. No, I did not mean a comparison as to who was ahead in it. But the thought struck me: We do have and we have had these stations, cooperative stations all over the world. You have them now.

Major HAMMOND. Yes, sir.

Mr. MILLER. Whereas the only thing that they can get—it is true they have a big country, they can go out into the Atlantic almost to the Pacific, across the broad part of Asia and Europe, but the rest

of it must have been pretty blank to them unless they had some ship sneak out someplace.

Major HAMMOND. We do know, Mr. Chairman, that they have been using the large radio telescope that belongs to the University of Manchester in England at Jodrell Bank.

Mr. MILLER. They have been using it?

Major HAMMOND. Oh, yes; the same as we have. As a matter of fact we will continue to use Jodrell Bank.

This is usually in conjunction with our deep space net. This is the type of device that it is.

We know that they have been using this and as I understand it—I again get this from the open literature—the Soviet prediction as to when their hard-landing lunar device—they predicted the time of impact to the particular minute that it would impact and later, about a day later, based upon Jodrell Bank information they revised their time of impact. So presumably they rely quite heavily upon Dr. Lovell and his instrument.

Mr. MILLER. Of course that is interesting, too.

Major HAMMOND. Yes, sir.

Mr. MILLER. I think that—I have no occasion or reason to say this, although I may be prejudiced on the part of my own people, I think they have done as good a job or better job than we have today in getting the big boost and all of that, but somehow or another I am not so convinced that they have had the refinement or have the equipment to do the job that we can. I think this is a field in which we have greater capability than they have.

Major HAMMOND. There is no doubt we have greater geographical coverage; yes, sir.

Mr. MILLER. I said greater capability.

Major HAMMOND. All right, sir.

Mr. MILLER. I think that NASA, your own group, can do as good a job as they can possibly do. I think we can get the instrumentation as good as they can.

Mr. DUCANDER. Mr. Chairman?

Mr. MILLER. Yes.

Mr. DUCANDER. Does NASA have a geodetic survey satellite program?

Major HAMMOND. Mr. Abbott?

Mr. ABBOTT. I think the answer to that is that we are planning one but that the program has not been formally approved at this moment.

Mr. DUCANDER. Isn't the Army interested in this, too?

Mr. ABBOTT. Oh, yes, the military are very much interested in this. This is a subject that I cannot cover in any detail in open session. It is likely, however, that there will be more than one.

Mr. DUCANDER. In other words NASA might have one and the Army as well.

Mr. ABBOTT. Yes.

Mr. DUCANDER. Or one of the military services as well.

Mr. ABBOTT. Yes, this is conceivable, because ours would be an unclassified operation with everything in the open, seeking, in effect, cooperation of other countries.

Mr. DUCANDER. I see.

Mr. ABBOTT. In the operation. If the military decide—and I do not know that they will—to do someting, it would be for their own special purposes.

Mr. DUCANDER. I see. Some of this equipment under Minitrack is for the use of such a satellite, a geodetic survey satellite?

Mr. ABBOTT. Yes, sir.

Mr. DUCANDER. And it is being included in this program on the basis that NASA anticipates that they may have a use for it.

Mr. ABBOTT. More than that. I am sure that we will have a use for it. Geodetic information can be obtained from several types of satellites. The only question at the moment is whether we will have a special satellite for this purpose or not.

Mr. MILLER. I notice that Major Hammond had said that part of this was the prototype——

Mr. ABBOTT. This was the meteorological program; yes, sir.

Mr. DUCANDER. Knowing that the Army was interested in this matter, Mr. Chairman, I just wanted the record to show that this is not going to be a duplication of effort.

Mr. ABBOTT. No, sir. This is a subject in which there is close cooperation and many discussions going on at the moment. Just exactly how this will be done is not finally resolved. However, it is safe to say that geodetic satellite will be done in such a manner as to satisfy the civilian and military needs. Whether this will be by separate programs or whether it will be a cooperative program still remains to be determined because there are many problems in this.

Mr. DUCANDER. Have you listed the anticipated locations of the Minitrack stations?

Major HAMMOND. I can give those to you very readily.

Mr. MILLER. I think they are set up.

Major HAMMOND. They are in the justifications.

Mr. DUCANDER. They are?

Major HAMMOND. Yes, sir. On page 420 right at the top of the page.

Mr. MILLER. They are in the justifications. You can read them into the record if you desire.

Mr. DUCANDER. Yes, the record should show it.

Major HAMMOND. The Minitrack stations that are currently in operation are located at Blossom Point, Md.; San Diego, Calif.; Fort Myers, Fla.; Antigua Islands, West Indies; Quito, Ecuador; Lima, Peru; Antofagasta, Chile; Santiago, Chile; Woomera, Australia; Esselen Park, South Africa, and the four stations that will be in operation later this calendar year are in Newfoundland; Fairbanks, Alaska; East Grand Forks, Minn.; and in England, for a total of 14 stations.

Mr. DUCANDER. The last four you mentioned are the ones you are asking the funds for?

Major HAMMOND. No, sir. There is some completion funds required here, but they are funds that will be used, for example at the bottom of page 424. We currently read the data from the Minitrack equipment by recording it on a strip tape. The station personnel then must read that visually and enter this information into a teletype machine for transmission back to the control center here in Washington. This equipment called for at the bottom of page 424

will do this automatically, will eliminate errors and will speed up the entire process.

Mr. DUCANDER. This is what I had in mind and I do not want to unduly take the subcommittee's time, but if a member on the floor picks up the bill and says "On page 3 line 4, various locations, tracking facilities $27,750,000, Mr. Miller, where are those stations going to be located?"—this is the type of question that is liable to come up on the floor—what should the chairman of the subcommittee reply?

Major HAMMOND. First of all the Minitrack stations I just read into the record is what should be answered on Minitrack. Let me also read into the record, if you would like, the deep space net locations and the Mercury.

Mr. MILLER. I think as we go into those we will put into the record each one of them but we will withhold that now.

Major HAMMOND. All right.

Mr. ABBOTT. Perhaps to be a little more responsive to Mr. Ducander's question about these four stations which are going into operation shortly, these have fundamentally been funded out of current funds. The funds which are now being requested are funds to improve the equipment for the whole network.

Major HAMMOND. For all stations.

Mr. ABBOTT. For all stations.

Mr. DUCANDER. I see.

Mr. MILLER. Now then, I think we have it pretty well completed unless there is something that you have, Judge, specifically about any of these.

Mr. CHENOWETH. There are going to be 14 stations altogether?

Major HAMMOND. Yes, sir.

Mr. CHENOWETH. Not all in operation now?

Major HAMMOND. No.

Mr. MILLER. But all of them will be this calendar year, most of them are, and four of them are not up to standard.

Mr. CHENOWETH. With the expenditure of these funds that brings the 14 into complete operation.

Major HAMMOND. Yes, sir. Let me add one more point: The Minitrack Network was originally built for the IGY period. It was so designed that it would track satellites in low-inclination orbits, in other words orbits that fly essentially near the equator, some 30 degrees off of the equator.

When you fly higher-inclination satellites, such as polar satellite, you now find that this original Minitrack Network will not perform the job adequately. The reason for that was that there was an antenna pattern that was oriented north and south for those low-inclination satellites to cut through. We now have added a second pattern oriented east and west that will now take care of those flying in the higher inclinations, you see.

Mr. MILLER. And eventually we are going to have to have a system pretty much around the equator, too. But that is in the future.

Major HAMMOND. This is a good subject, Mr. Chairman, if you would like to discuss it.

Mr. MILLER. No, because I think when we begin to get some refinements we have got to go there.

Major HAMMOND. Perhaps.

Mr. MILLER. Then if there are no other questions we will pass on to the deep space net, $8 million.

Major HAMMOND. The deep space net now for the record: the stations are located at Goldstone, Calif.; Woomera, Australia, and near Johannesburg, in the Union of South Africa. Goldstone is currently operational, Woomera will be operational this year, and South Africa at the beginning of the calendar year 1961.

Mr. DUCANDER. These construction funds are to complete stations already established?

Major HAMMOND. Yes, sir; right.

Mr. DUCANDER. All right.

Major HAMMOND. You must appreciate, gentlemen, that the deep space net consists of these huge 85-foot diameter antennas. The reason you have such a huge antenna is because you are getting such a minute quantity of radio frequency energy back from the deep space probe. To give you an example, the station at Goldstone on Pioneer IV last March tracked a signal out to some 400,000 miles. This signal, in strength, was about equivalent to one-half the power that is required to light a two-cell flashlight bulb. So the location of these now must be in a geographical area where there is a minimum of noise, you see, a minimum of automobile traffic, a minimum of even radio receivers which, although they are receivers, they still cause noise for such equipment as sensitive as this, you see. Therefore when you see our items here——

Mr. MILLER. When you say noise now, sound, you are talking about the electric emanations that are given off that can blanket or destroy the signal?

Major HAMMOND. Yes, sir.

Mr. MILLER. For instance I live in the Methodist Building. Our television is on and every night at 11 o'clock there is a plane takes off and flies pretty close there. We know it is coming before we hear it. And until it gets pretty well out of the way we get jiggles on our television. This is the very thing that you have got to avoid—only this is a very simple, the most simple type of thing.

Major HAMMOND. Right.

Mr. MILLER. But when you speak of noise this is the type of noise you mean, these electric things that come out that can destroy the efficiency of these great machines.

Major HAMMOND. Yes, sir.

I might add that prior to placing a station, a very complete survey must be made of even the magnetic fields in the particular area where you are going to put one of these stations. This again emphasizes the importance of putting these things in a radio-quiet area.

Mr. MILLER. Do you have, now, say in the case of Goldstone which is well isolated at the present time, do you have any easements to prevent anything coming out there in that vicinity?

Major HAMMOND. That property out there is on the reservation at Camp Irwin.

Mr. MILLER. It is on the reservation which gives you the easement?

Major HAMMOND. Yes, sir.

Mr. ABBOTT. In the particular case of Goldstone, there is a fortunate circumstance there in that the antenna is shielded, itself, by

the topography of the land in such a way that radio emanations coming in from the cities and other activities which are not too far away are blanketed and the antenna, itself, is in a dead region.

Mr. MILLER. It is not a very good television reception area from the stations that you have out around there?

Major HAMMOND. Right where this antenna is located, it would be a very poor television reception area.

Mr. MILLER. I used to drive up and down California. In the old days you would want to pick up stations; you would be almost within a few miles of some of the powerful stations in San Francisco and you could not get them, but you could get a station in Fresno. Then you run out of that one going down the coast road and then pick up another one which you thought was a long way off. It was this same thing. There are valleys there where they could not get through. I got so where I could judge pretty good where I was by the radio service.

Major HAMMOND. This is radio navigation, Mr. Chairman.

I might add that this same type of topography also determined our location in Australia and South Africa, a bowl-type of terrain where the antenna can be put in the bottom of the bowl.

Mr. MILLER. I assume—that part of California is pretty wild country.

Major HAMMOND. Yes, sir.

Mr. MILLER. Getting back, the first two items are for construction and permanent support facilities. I presume at these places you will have to put in housing and so forth for your people.

Major HAMMOND. Yes, sir, definitely; they are quite remote areas.

Mr. MILLER. In these permanent support facilities what will that consist of?

Major HAMMOND. I can give you details on that, sir.

There will be some $700,000 of $1.7 million spent at Woomera, some $710,000 in South Africa, and $290,000 at Goldstone.

In the $1.3 million, the construction of technical facilities—this is such items, incidentally, as the air conditioning for the electronic equipment, the operations buildings that are associated with those antennas. And when you change frequencies, when you are tracking, for example, on 900 megacycles and then you want to change to say 200 megacycles to track on one of these big antennas, you must physically change the antenna. You must physically get out to the feed point on the antenna and make certain physical mechanical changes. Now, to visualize an 85-foot diameter antenna, the feed point being some 100 feet in the air, it requires some feed servicing towers to enable one to make these changes promptly. This, incidentally, is about a 12- to 18-hour process when you change frequencies. It is quite unlike changing the channel on one's TV set.

Mr. DUCANDER. Do we take a lease from the foreign government concerned when we put this construction on?

Major HAMMOND. Yes, sir. These agreements are—if not completed at this time, they will be essentially any day now. Our people in conjunction with the State Department have been to these various countries.

Mr. MILLER. Now, I trust that when you talk about air conditioning—I realize that you need it, there is certain mechanical stuff that has to be kept at pretty constant temperature—but I hope you do not forget it in the homes of some of the personnel, too.

Major HAMMOND. These homes are essentially dormitories, Mr. Chairman, of course, and they certainly would have, let's say, the comforts for a reasonable type of living out there. We must have a fairly high grade of personnel at these stations. An awful lot depends on the operation of these stations. The several millions of dollars going into the deep space probe——

Mr. MILLER. I think it is essential if these people are going to work out in this country.

Mr. DUCANDER. These are lonely places, too.

Mr. MILLER. I am reminded—off the record.

(Discussion off the record.)

Mr. MILLER. Now then, to improve receiving, tracking support equipment and the trajectory measurement equipment, this is all highly technical.

Major HAMMOND. Yes, sir.

Mr. MILLER. We will just have to take that——

Major HAMMOND. These funds will be distributed between the three stations, incidentally.

Mr. MILLER. The three stations.

Major HAMMOND. Again, they are to provide the extremely sensitive receiving equipment that is necessary at these various stations. When you are talking in terms of receiving from hundreds of thousands of miles a good deal less than one single watt of power, you have a real receiving problem on your hands.

Mr. MILLER. And the other $1 million for the data-process equipment for tracking and telemetering, the data-process and handling equipment—the same argument holds there that you mentioned, I assume, a minute ago, in the case of the Minitrack; you have got to get the data back?

Major HAMMOND. Yes, sir, very definitely; particularly during the early stages of the flight when the commands are sent to the vehicle to correct its trajectory, it is quite important to get these commands to the vehicle early in its trajectory. Then, again, as it approaches its destination—for example, a landing on the moon—again you must be able to translate data very rapidly so you can make proper corrections for the landing.

Mr. MILLER. Any more question?

Mr. CHENOWETH. Off the record.

(Discussion off the record.)

Mr. DUCANDER. On the record.

When this system is complete, will we have a capability similar to that of Jodrell Bank?

Major HAMMOND. No. First of all, Jodrell Bank is only one station, and it must be—the point, I believe, that the chairman made with regard to the homeland of Russia, Jodrell Bank can only be effective when England is underneath the vehicle, you see.

Mr. MILLER. The vehicle?

Major HAMMOND. Yes.

And furthermore, Jodrell Bank is some 250 feet in diameter as opposed to our 85 feet. This gives him a greater amount of amplification and he could track farther. However, this deep space net will take care of our missions for the next few years until our propulsion is improved.

Mr. DUCANDER. Do you know of any plans for the United States to attempt to have the same capability as Jodrell Bank?

Major HAMMOND. We have in our long-range plans either one of two approaches. First of all, you can put two of the 85-foot antennas together and so phase them that they give you the equivalent of the double area, you see. Actually, at Goldstone, we do have two dishes. One is used for receiving and one is used for transmitting signals to the vehicle.

Now, you can use both of these together as receiving devices and you have double the area of one—which gives you the effect of having twice as big a dish in area.

Now, whether we will take this approach or whether we will go for a bigger dish at our stations will be the function of studies that are currently underway.

Mr. DUCANDER. I see.

Mr. ABBOTT. There is one point here that might be made. Jodrell Bank is, of course, primarily an astronomical station and this accounts for the very large size of the dish. This country also is in the process of putting up large astronomical installations in West Virginia.

Mr. MILLER. I was going to say we have one going in over there.

Mr. ABBOTT. These astronomical stations, although they are very good for reaching out great distances and receiving signals because of the size of the dish, also suffer from the point of view of space work from some other limitations. Because of the large sizes of the dish they cannot track very rapidly, for instance. They don't have to for astronomical purposes.

The difficulties previously mentioned about changing frequencies rapidly becomes even more of a problem on these big installations. But undoubtedly all available astronomical installations will be used wherever appropriate for space work to supplement the space net. But they cannot replace it.

Mr. DUCANDER. I see.

Mr. MILLER. Under whose jurisdiction will this installation in West Virginia fall? Will that be NASA?

Mr. DUCANDER. It is Navy, isn't it?

Major HAMMOND. Actually, there will be three dishes, three large antennas put at the installation in West Virginia, Sugar Grove, W. Va.

The Navy, yes, in 1962, I believe, will have a 600-foot diameter antenna available there in operation.

The National Radio Astronomy Observatory, which I believe is an element of the National Science Foundation, currently has an 85-foot antenna similar to the one we have in Goldstone, and are currently constructing, a 140-foot diameter antenna. This will be available in December of 1960.

Mr. MILLER. The National Science Foundation is putting that up?

Major HAMMOND. Yes, sir.

Mr. MILLER. That is one of our babies.

Mr. DUCANDER. Yes, sir.

Mr. ABBOTT. The National Science Foundation, I believe, operates it through a group of associated universities.

Mr. MILLER. Yes.

This is off the record.

(Discussion off the record.)

Mr. MILLER. That takes care of this $8 million on the deep space net.

Have you any further questions?

Mr. CHENOWETH. No questions.

Mr. DUCANDER. No questions.

Mr. MILLER. Thank you.

Then, suppose we go to the Mercury net, which is $15 million.

Major HAMMOND. All right, sir.

To get the stations into the record——

Mr. MILLER. Oh, yes, the stations in the record.

Major HAMMOND. I may have to do this one from memory.

Mr. MILLER. Is this for the deep space?

Major HAMMOND. I put that in.

Now, on the Mercury stations——

Mr. MILLER. I don't remember them.

Mr. DUCANDER. I don't think they are listed.

Major HAMMOND. I have them here. I will read them into the record.

Mr. MILLER. Fine.

Major HAMMOND. Cape Canaveral, Grand Bahama Island, and Grand Turk Island. These are considered as one station, the Atlantic Missile Range Station.

Bermuda; a mid-Atlantic ship; Canary Islands; Kano, Nigeria; Zanzibar; Indian Ocean ship; West Australia, near perth; Woomera, Australia; Canton Island; Hawaii; southern California; West Mexico; White Sands Missile Range; south Texas; Eglin Air Force Base; and the Computing and Communications Center at Goddard Space Flight Center at Beltsville, Md., and the Control Center at Cape Canaveral.

Mr. DUCANDER. Is the station on Hawaii at Kaena Point?

Major HAMMOND. It is on the island of Kauai, and I don't believe it is at——

Mr. DUCANDER. Kaena Point——

Mr. ABBOTT. No, it is not the Kaena Point Station.

Mr. DUCANDER. Yes, sir, I was there, too.

Mr. ABBOTT. The station that will be used is the one at Barking Sands.

Mr. MILLER. That is up on Kauai.

Major HAMMOND. I beg pardon. Some of the Navy equipment was at Barking Sands. However, the topography of the Barking Sands area was not quite proper. So this equipment is being moved up into the mountains behind Barking Sands.

Mr. DUCANDER. Kaena Point, I was out there last year and went up there.

They are tracking Discoverer at that station and also they told me that that was the station that would trigger off the descent of the Mercury capsule. Is that correct?

As a matter of fact, they showed me the button they would push.

Major HAMMOND. You are right and wrong, yes, sir, Mr. Ducander. First of all, the actual equipment that you saw will not be the equipment to be used. It will be some similar equipment.

In studying this very carefully with the Ballistic Missile Division people in charge of the Discoverer program, it turns out that there was a complete conflict in schedules. Both programs being of relatively high priority, it turned out that we in NASA found that we could get some surplus 584 radars, modify them into the type of equipment that is known as a Verlort radar, long range S-band tracking radar, and this is part of the equipment that will be put in the mountains on the Island of Kauai to perform the function that you mentioned; namely, giving the command to the timing device that initiates the retrorocket action for the descent of the Mercury capsule.

Mr. DUCANDER. I think this would be a good time to ask this question, Mr. Chairman; I believe it is one that should be in the record because it is possible that you might be asked about it.

Now, we have in this request for authorization a request for funds from the Mercury net, the Minitrack, and deep space net. At the same time, we have the Navy Space Surveillance System, the Air Force Space Track System, and the Air Force Discoverer net.

Now, are there any duplications with your systems and the Armed Services systems?

Major HAMMOND. I would say no, and I believe I can speak with a bit of authority on this, since I was the Headquarters ARDC project officer on Space Track, and was involved in some of the early planning meetings on the Navy's space surveillance equipment.

The Navy Spacesur system and the Air Force Space Track system which must work together are for a quite different purpose, more of a defense type of purpose than our instruments.

Our instruments cannot track a nonradiating satellite, except by sheer chance, if we by sheer chance happen to see with one of our optical devices a nonradiating satellite, then we can track it.

We do, however, based upon information from Space Track, use our optical instruments to help them to supplement their tracking, because they tell us where to look, to find it.

Mr. DUCANDER. I see. In other words, each has its own mission?

Major HAMMOND. Very definitely.

Mr. DUCANDER. And therefore they don't duplicate.

Major HAMMOND. Yes, sir.

Mr. DUCANDER. But you do have a good liaison between—one complements the other. Is that a correct statement?

Major HAMMOND. I would say so; yes. The Spacesur system is primarily for detection. This is its major attribute, major contribution, that of detection. There is no other device except some high-powered radars that, again, are very narrow beam width, and they more or less have to know where to look.

Mr. DUCANDER. The Air Force Discoverer net is for a particular program.

Major HAMMOND. You are absolutely right. That is quite another subject, you see. That is a net of five or six stations that—this equipment is so designed that it can track and derive data from the Dis-

coverer satellite and issue commands to the Discoverer satellite on the given frequencies in the particular type of language or coding that that satellite likes to hear.

Mr. DUCANDER. Do you know of any other stations or nets aside from the ones you have in the bill here and the ones that I have mentioned of the armed services?

Major HAMMOND. There are applicable instruments at various places, such as a radar at the Atlantic Missile Range, which incidentally we use in our Mercury net when it is applicable. However, as far as nets are concerned; no, sir.

Mr. DUCANDER. Thank you. I just wanted the record to show that.

Mr. CHENOWETH. Is there any duplication of effort in this field? Mr. Ducander mentioned three different——

Mr. DUCANDER. The armed services nets. That is the Navy space surveillance system, the Air Force space track system, and the Air Force Discoverer net, plus the three that he mentioned.

Mr. CHENOWETH. There is no way to build one system which would take care of all of these?

Major HAMMOND. No, sir. Our three nets, speaking only of the NASA nets, these three nets are so designed and so built that they cannot adequately do the job of the others, because the jobs are quite different.

The deep space net, as I said, consists of huge antennas, they are tracking hundreds of thousands of miles, very minute signals.

The Mercury net must be very rapid in its reaction because of the real-time nature, you must derive the position information of the capsule as it is flying.

The minitrack network is a system that keeps track and derives data from a satellite that will be up months and years.

They are quite different.

Mr. CHENOWETH. How many of these different instruments are there going to be around the world altogether? How many do we have right now?

Major HAMMOND. I would say that as far as NASA is concerned, we are in very good shape as far as getting the necessary data back from our missions, be the mission one of deep space probe, vertical probe, Earth satellite or manned satellite.

Mr. CHENOWETH. The completion, then, of this program for which you are asking the funds now will virtually complete the program so far as NASA is concerned, or will you have further requests, further needs? Or is this going to pretty well give you what you want?

Major HAMMOND. This will give us what we need for the foreseeable future, for the planned programs that we have to support at this time.

Now, as people in Dr. Abbott's capacity, for example, think up new problems for we instrumentation people, we will probably be back asking for more funds in subsequent years; yes, sir.

We simply have to meet the requirements of the scientific experimenter.

Mr. ABBOTT. Perhaps I should say something about this whole problem. I participated last fall for about 3 months in a very intensive joint Department of Defense-NASA management exercise

on this whole problem, to try to find out what the score is. Actually, I think the situation is pretty good.

Now, coordination is taking place on a day-to-day basis between people in the Department of Defense, including the military services and NASA. It is probable that some more formal mechanism for coordination will be set up, but nevertheless coordination is taking place now very thoroughly on this matter.

Basically, what we have—when I say "we" now, I mean the United States—on this tracking system, are the following:

There is the minitrack net, which is a general purpose satellite net and serves a great many of general purpose things, both for the Department of Defense as well as for ourselves.

There is the deep space net, which has been coordinated with the Department of Defense, and there will be the one deep space net and only the one deep space net which is needed for these deep space probes, lunar missions, and this sort of thing.

Mr. CHENOWETH. The minitrack has the 14 stations?

Mr. ABBOTT. The minitrack has the 14, deep space has basically the 3 stations.

Mr. CHENOWETH. Three; yes.

Mr. ABBOTT. Now, on top of this, as far as NASA is concerned, we are putting in the special purpose Mercury net. This special purpose net is making use of installed equipment already existing on this great circle that the Mercury capsule is going to traverse, wherever possible.

That is, such as at Cape Canaveral; Grand Bahama; Grand Turk; Woomera, Australian; Eglin Air Force Base, other places like that.

In addition to that, it is making use of a new station at Bermuda which will be the only additional permanent station in the Mercury net, and is being made permanent not because of the Mercury net but because it will serve as a down-range station for Wallops, which is badly needed. All the other things which are being put in for the Mercury net in the various places that Major Hammond has mentioned, is being put in in the form of equipment which can be picked up and moved as required at later date for other purposes.

So it will constitute a net for the life of the Mercury project, but then the same equipment can be picked up, moved to other localities, to form another net that may be needed later on for other purposes.

Mr. CHENOWETH. How many stations are in the Mercury net?

Major HAMMOND. It will be 18, counting the control points.

Mr. CHENOWETH. Eighteen.

Major HAMMOND. Yes.

Mr. ABBOTT. Now, on top of this, what we have in the United States are essentially the other nets which were mentioned by Mr. Ducander. There is the surveillance net, which is for a very special defense purpose. It is to find unradiating objects, and you will remember they succeeded in locating one recently.

Then, you have special purpose nets that the military will have to put up from time to time, such as the Discoverer net.

Mr. CHENOWETH. Are these worldwide?

Mr. ABBOTT. These may not necessarily be all the way around the world. It will depend upon the military mission which they wish to perform. But where they have a very definite military mission to perform, they will find it necessary to put in a special system to do

that. But this, I believe, is unavoidable and is associated with the project.

The only other thing that we have that complicates the picture is that we do have these extensive missile ranges, Atlantic Missile Range and the Pacific Missile Range, primarily, with Eglin getting into the picture.

These missile ranges do, of course, have types of equipment which are useful for space work but they are there primarily for the military missile purposes and are needed for those purposes, and will be used, both by the Department of Defense and by ourselves whenever the equipment is available for the space work to avoid putting in other things.

So that I do not believe that we have an extensive duplication at all, and it really is very hard to to find any duplication.

Mr. CHENOWETH. You have got these three nets, minitrack, deep space, and the Mercury, for the Space Agency?

Mr. ABBOTT. Yes, sir.

Mr. CHENOWETH. The Air Force has some, Army has some, Navy has others. I just wonder how complicated this whole system is getting.

Mr. ABBOTT. I think it appears to be more complicated than it really is. The Air Force is running the Atlantic Missile Range, for instance, but the Air Force runs the Atlantic Missile Range as a service to everybody that goes into the range, including not only other military services, but NASA. We are making extensive use of it.

The Pacific Missile Range is under cognizance of the Navy, but again the Navy is operating this range as a service organization and they serve everybody. They have given extensive service to the Air Force. At the present time, there are very definite plans for Army utilization of it, and we will be using it, too.

Mr. CHENOWETH. The reason I mention this, there are those who are critical of course of the whole space program and are trying to find all the faults they can. This might be a place where we might be vulnerable.

They say here: Look at all this duplication of effort. Why shouldn't there be one agency that supervises all of these nets? They are just duplicating each other, each one is trying to outdo the other, see how extensive he can go.

You see, we are in a field we know nothing about. Not being scientists, we can't—I can't. The Chairman here has more experience and knowledge than I have in these things, but the ordinary Member of Congress does not understand the technical and scientific implications involved.

Mr. ABBOTT. Yes, sir. On the surface it looks like very bad management. Actually, I think it is working out very well.

Mr. CHENOWETH. We have faith in you. We are just going to have to defend what you and the others are doing, because from a scientific standpoint we just don't have that information. We have to have confidence that you are doing what is best and that you are trying to conserve funds where you can.

Mr. ABBOTT. I think a good example of how this thing is working out and working out very well is in connection with the Mercury

net, where we are of course making extensive utilization of Department of Defense facilities throughout the world.

On this the Department of Defense has set up General Yates, who is also the commander of the Atlantic Missile Range, as a single contact point with command authority in the Department of Defense for this Mercury operation throughout the world. So that we have one man that we can go to and he has the authority to coordinate this in the Department of Defense, not only in the Air Force and his own Atlantic Missile Range, but throughout the services, his authority in this respect evolving directly from the Chiefs of Staff.

Mr. CHENOWETH. Has he just recently been given that assignment?

Mr. ABBOTT. He was given this assignment 6 months ago or thereabouts. And it is working out extremely well.

Major HAMMOND. Would it be helpful if we read into the record those stations of the Mercury net that are Department of Defense stations that are already there?

Mr. MILLER. Yes.

Mr. CHENOWETH. I think that would be very helpful.

Major HAMMOND. Cape Canaveral; Woomera, Australia—this, of course, is not our Department of Defense but it is the Australian equipment that is being used by NASA—Hawaii; southern California, PMR; White Sands Missile Range; and Eglin Air Force Base.

Mr. MILLER. Just running down very rapidly here the ones that we can understand: You are asking for $2,400,000 for station construction, and you got $2,245,000 last year. This is the next increment to complete the construction in the 1961 year?

Major HAMMOND. Yes, sir. You will notice 2,245,000 is the fiscal year 1960 supplemental.

Mr. MILLER. That is the 1960 supplemental?

Major HAMMOND. Yes, sir.

Mr. MILLER. Will this complete all of it, or will you have to come back in the future?

Major HAMMOND. This will complete the Mercury net.

Mr. MILLER. The Mercury net?

Major HAMMOND. Yes, sir.

Mr. MILLER. And this $2.4 million is used throughout the whole 18 stations?

Major HAMMOND. Throughout; yes, sir.

Mr. MILLER. Let's see what else we have got here. Seaborne radar stabilization equipment——

Major HAMMOND. I believe you missed one, the S-band radar equipment for $400,000.

Mr. MILLER. The S-band, that is the one?

Major HAMMOND. Right. That plus the supplemental request was made necessary when we had to put in our own S-band radars at those Discoverer stations that Mr. Ducander brought out when it was found out about the conflict in programs.

Mr. MILLER. The seaborne radar stabilization equipment.

Major HAMMOND. I would like to say for the record, Mr. Chairman, that that is not definitely established at this time, whether that will be a land- or sea-based station. This will be a function of the negotiations with the Mexican Government.

Mr. MILLER. Radar accessory and modification. That is just bringing them up to date?

Major HAMMOND. Yes, sir. Spare parts——

Mr. MILLER. Improvements in ground communication system, that is part of your data processing and handling?

Major HAMMOND. Right. This is the operational and administrative integration of all of these stations.

These funds, incidentally, are for the procurement of capital equipment. You would find in our "Research and development" budget, under "Operations," the funds to pay the tariff charges on the lines that we must lease.

Mr. MILLER. What is this telemetry and radar data processing and display equipment?

Major HAMMOND. The funds there are for—well, let me explain just a bit here, first.

As the capsule flies, you will find that the occupant will be in communication with the ground stations. At each ground station we will have medically trained people as well as people that are familiar with the capsule environment and will, in effect, be able to diagnose the astronaut's health, if you will, as he flies over the station. The telemetering display equipment at each station will be presenting information relative to this man's heart actions and what have you.

Furthermore, these funds are to equip the control point at Cape Canaveral.

Mr. CHENOWETH. Right there, may I ask a question?

Major HAMMOND. Yes, sir.

Mr. CHENOWETH. What could we do about it if we find out something does go wrong?

Major HAMMOND. You can bring him down at the earliest opportunity. There is provision for a recovery area in each orbit.

Mr. CHENOWETH. Before the orbit is completed, then?

Major HAMMOND. At the completion of the orbit, yes. It would be better to leave him in orbit than to simply bring him down at any place because he would be hopelessly lost, you see.

Mr. CHENOWETH. The orbit would take about an hour and a half, wouldn't it?

Major HAMMOND. No, sir. The orbit on this, it is a low altitude, I think it is only in the order of 90 minutes—well, yes, of course——

[Laughter]

Major HAMMOND. This always throws me.

Mr. CHENOWETH. I had that impression.

Mr. MILLER. Well, anyway, it also tells us the mistakes, if anything does go wrong, we want to know it, because this is one of the reasons you are sending him up, to know the mistakes we have made.

Major HAMMOND. Yes, sir.

Mr. CHENOWETH. In other words, he has to complete that orbit? Supposing something goes wrong within the first 15 minutes, say, you are going to let him complete the orbit.

Major HAMMOND. Within the first 15 minutes I think he could still be recovered.

Mr. CHENOWETH. When does he pass that point from which there is no return? I don't care for the minute detail.

Major HAMMOND. I think about 15 minutes, yes, sir.

Now, what happens if something goes wrong after that? First of all, the probabilities of something happening are much higher in that first 15 minutes. The probability is perhaps the greatest of something happening right at launch.

The next most probable place where something will go wrong is at the point of the injection of the capsule into orbit.

Mr. CHENOWETH. How many minutes is that?

Major HAMMOND. I think about 5 to 6 minutes.

Mr. CHENOWETH. How far apart will these stations be, where you can track him to find out just what is going on, in time?

Major HAMMOND. In time?

Mr. CHENOWETH. You say there are 18 of them altogether.

Major HAMMOND. They do not all track, however.

Mr. MILLER. These stations——

Major HAMMOND. Let me also read into the record the number of those that track.

Mr. CHENOWETH. Yes, I would like to know that.

Major HAMMOND. All right, sir. You appreciate the difference between tracking and simply gathering telemetering data?

Mr. CHENOWETH. By tracking, you mean they are getting full information on the capsule?

Major HAMMOND. By "tracking," I mean that they are measuring where he is in space with respect to some position on the Earth, you see. This is the term "tracking."

Mr. CHENOWETH. How about getting his physical condition, that is not part of tracking?

Major HAMMOND. No, sir. The physical condition—you are right, this is transmitted back to each one of the stations.

Mr. CHENOWETH. Each one?

Major HAMMOND. Yes, sir.

Mr. CHENOWETH. Each one of the 18?

Major HAMMOND. Each one of the 18.

Mr. CHENOWETH. Each one will get that?

Major HAMMOND. Yes, sir. Furthermore, each one of these stations will be able to have voice communication.

Mr. CHENOWETH. Voice communication?

Major HAMMOND. Yes, sir.

Mr. CHENOWETH. Is that right?

Major HAMMOND. Right.

The stations are so planned that there is approximately 5 minutes out of every 15 that you will be able to communicate with the astronaut.

Mr. CHENOWETH. Five minutes out of every 15?

Major HAMMOND. Yes, sir.

Mr. CHENOWETH. A third of the time.

Major HAMMOND. Yes, sir. This was one of the criteria that went into the design of the network.

Mr. CHENOWETH. He would be in touch with one of these stations, then?

Major HAMMOND. Right. As I pointed out, each station has the trained personnel there that are familiar with the life support of the capsule and things of this nature. So they will be able to detect—if, for example, the capsule has something wrong with the oxygen

supply, in which case he will be able to tell this, too, by his own instruments in the capsule, and furthermore the ground station will be able to alert him to this, and he can then go on his suit auxiliary oxygen supply.

Mr. CHENOWETH. Is he going to have any control of the capsule, himself? Or does that all depend on these tracking stations?

Major HAMMOND. Are you familiar with that, Mr. Abbott?

Mr. ABBOTT. Yes, sir.

This is a completely joint system. He can have full control. Full control can be had from the ground or any combination.

Mr. MILLER. There was a good television program on this yesterday. I don't know whether you saw it.

Mr. ABBOTT. I am sorry, I did not see it.

But everything is duplicated at least twice.

Mr. CHENOWETH. Who is going to make a decision whether his orbit should be interrupted, whether it has reached a point——

Major HAMMOND. I can even tell you the gentleman's name. Mr. Walter Williams, NASA man, has been designated as the responsible person for this decision.

Mr. CHENOWETH. The decision will have to be made very quickly?

Major HAMMOND. Very definitely. This is precisely why you cannot use the minitrack network to do this job, you see. There is one of your basic differences.

Mr. CHENOWETH. Yes, sir.

Mr. MILLER. All right. Without further ado, you are satisfied with this, I take it?

Mr. CHENOWETH. I am.

Mr. MILLER. Thank you very much, Mr. Abbott and Major. I want to tell you that I have gotten a great deal out of this. I have enjoyed it.

Mr. ABBOTT. Thank you, too, Mr. Chairman. We appreciate this opportunity a great deal.

Mr. MILLER. This is just fascinating.

(Whereupon, at 12:11 p.m., the subcommittee adjourned, to reconvene at the call of the Chair.)

[EXECUTIVE SESSION]

1961 NASA AUTHORIZATION

THURSDAY, FEBRUARY 18, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE NO. 2,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2:10 p.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. Last year we asked the people that were up here if they would take each one of these—we may get most of it before we get through—and in as much detail as possible say just what you would say if you were over on the floor trying to tell the other Members of Congress why we should spend this money and what it is going for.

That is a lot of work for you people, but actually it is what we need to use over there.

Would you agree with that Mr. Bass, Mr. Karth?

Mr. BASS. I would think so.

Mr. KARTH. Very much so.

Mr. TEAGUE. I would like you to prepare what you would say to somebody on the floor who has heard none of the technical hearings, and knows little about it. Otherwise there is a good chance before this is over that you will get cut in appropriations just exactly the way you got cut last year, and you can't be cut 10 percent and not be hurt.

We have to get the best information from you people. We don't have it—I don't. As much as I read and hear I still need whatever you prepare on each of these subjects, just as though you were talking to somebody who didn't know what it is all about, because that is what we must do. These are complicated programs, and we need their explanation in layman's language because the same concentration we are putting in on this, they are putting in on agriculture or a "jillion" other things.

STATEMENT OF DR. ABE SILVERSTEIN, DIRECTOR OF SPACE FLIGHT PROGRAMS; ACCOMPANIED BY MILTON B. AMES, DEPUTY DIRECTOR, OFFICE OF ADVANCED RESEARCH PROGRAMS; WESLEY HJORNEVIK, DEPUTY DIRECTOR, OFFICE OF BUSINESS ADMINISTRATION; THOMAS E. JENKINS, ASSISTANT DIRECTOR, OFFICE OF SPACE FLIGHT PROGRAMS; MORTON J. STOLLER, ASSISTANT DIRECTOR, SATELLITE AND SOUNDING ROCKET PROGRAMS; AND CHARLES J. DONLAN, ASSISTANT DIRECTOR FOR PROJECT MERCURY, REPRESENTING THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. SILVERSTEIN. We will prepare for you a series of documents that will enable you to provide an understanding to the members of Congress on our subject areas.

Mr. TEAGUE. If feasible, if practicable. I can always do a much better job if I have been someplace and seen what I am talking about.

Dr. SILVERSTEIN. We have been very anxious to have the members of the committee visit the various NASA installations.

Mr. TEAGUE. Anything you members want to say?

Mr. KARTH. I would just say this, Mr. Chairman, that they are specially well prepared in giving us the reasons for large increases in these same areas.

Mr. TEAGUE. That we had last year.

Mr. KARTH. Where last year there were substantially less funds appropriated you see, or requested, to support the NASA plant for example. There are good reasons for it, going from $1 million up to $22½ million, and then to $51 million, but I think you have to do a specially good job in preparing the whys and wherefores in those instances.

Mr. TEAGUE. That is a very good point. You can sit up on the floor and add up two and two; you may not know a thing about it and you can see this increase and you are sure to be asked why that amount this year.

Mr. KARTH. It was $1 million and $22 million last year, and of course $51 million this year. This is a big step and they will want to know why.

Mr. TEAGUE. We are trying to help, and the amount of help we can give you will depend a lot on what you people can do.

Shall we start with page 110?

Dr. SILVERSTEIN. Mr. Chairman, I thought maybe in starting this it might be a good idea to refresh your mind on the flight program associated with the major elements in these four categories we are discussing. A large percentage of the funds that we will discuss in our meeting will be aimed at the support of the flight programs that are carried on by us in the various areas of sounding rockets, satellites, lunar probes, meterological programs, and manned flight.

I thought I could review very briefly the charts I presented to the committee showing our flight program, and use this as a focal point for discussions later of the details of the program. Would this be satisfactory?

Mr. TEAGUE. That would be satisfactory.

Dr. SILVERSTEIN. We have shown on these three charts the flight program that we are proposing in the several years ahead. This is fiscal year 1960, 1961, 1962, and 1963 (fig. 7).

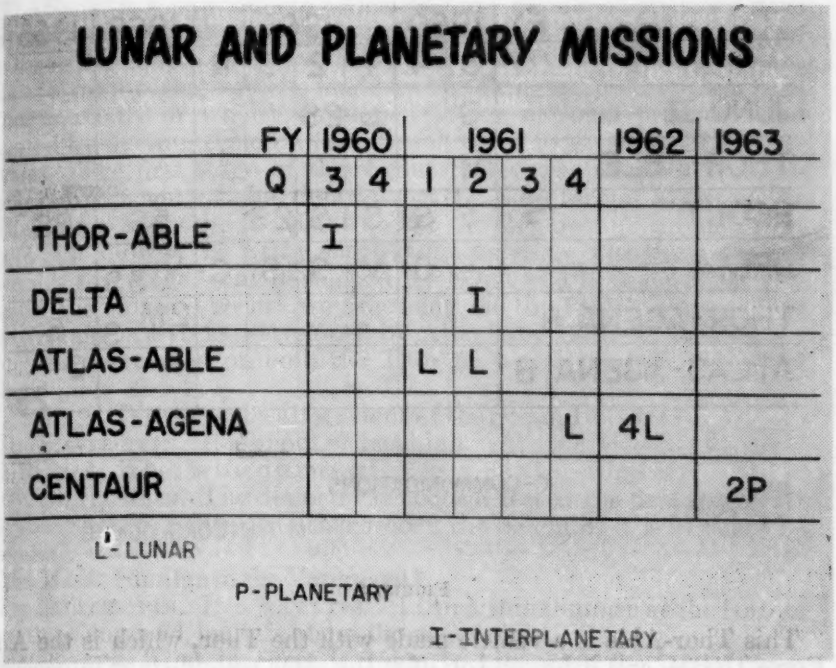

FIGURE 7

Our funding for these advanced programs has to start in fiscal 1960 and 1961, so that the leadtime we need on these very complicated pieces of equipment we are building will be available.

Mr. TEAGUE. Doctor, run through each one of those right quickly for us, Juno II, Thor-Able, and Scout, and so forth.

Dr. SILVERSTEIN. These designate the vehicles we are flying the scientific satellites with (fig. 8, p. 126): The Juno II is a vehicle which has been used in several of our previous firings. It is made up of a first stage booster, which is the Jupiter. The Jupiter, you know, is the IRBM that the Army built in Huntsville. On top of this we have a cage of solid rockets that form the upper stages. There are 15 of them—11 in the second stage, 3 in the third stage, and 1 in the fourth, and they fire in series, first the 11 fire, then the 3 fire and then the 1 fires, to provide the final velocity to the payload. The vehicle will carry a payload of about 85 pounds in a 300 mile circular orbit. We have used it within our program as a launch vehicle. It is a somewhat larger vehicle than the Explorer, the first satellite vehicle we used. Instead of the Redstone in the first stage we used the Jupiter. The Jupiter is twice as big as the Redstone.

52493—60——9

EARTH SATELLITE MISSIONS

FY	1960		1961				1962	1963
Q	3	4	1	2	3	4		
JUNO II	S		S	2S				
THOR-ABLE	M							
SCOUT		S	S	S	2S		5S	2S
DELTA		C	M	S	S	C	C 3S	
THOR-AGENA B							2M S	S
ATLAS-AGENA B								C 2S

S-SCIENTIFIC

C-COMMUNICATIONS

M-METEOROLOGICAL

FIGURE 8

This Thor-Able is a vehicle made with the Thor, which is the Air Force IRBM, and it has on top of it the same second stage in general configuration and the same third stage that is used on the Vanguard rocket.

This vehicle was developed by the Air Force originally to do some of their work on nose cone heating of firing not in orbit, but on ballistic trajectory and has been used by us in our program before.

Mr. TEAGUE. There you say the Thor-Able is meteorological. This will be for the meteorological mission?

Dr. SILVERSTEIN. Yes. We have 2 more vehicles we call Thor-Ables, although we have in the program the Delta which has basically the same components as the Thor-Able, and there are 12 of those in the program.

Mr. TEAGUE. Going back to Juno, the Juno engine will be used for scientific satellites?

Dr. SILVERSTEIN. Yes. This Thor-Able is used for the meteorological program, and then the next chart you will find another one of these vehicles that is shown for this flight we are to make very soon and which we are going to fire a payload far out into space.

So we have two of these in our program. I might point out both of these vehicles phase out of our program. These are vehicles we have put together to get the space program on the road. They are useful vehicles. This vehicle has quite a good record. This Juno I say is a modification of the vehicle we put the Explorer in space with.

Our program certainly can't wait for the development of new vehicles with nothing going on currently, so what we have done is adapt existing vehicles to the job.

The Scout is a new vehicle which we have developed since we have been in business, and which soon is to go into flight operation, as you can see in this fourth quarter of fiscal year 1960.

It is a solid rocket vehicle, made up by taking solids that have been either partially or wholly developed in our national program, and adapted by putting them on top of each other to give us satellite velocities. The first stage of this Scout rocket was adapted from an early development of the Polaris rocket. The second stage of the rocket came from the Sergeant rocket development program. Sergeant, you know is the Army short-range missile. The third stage is a wholly new stage being developed for Scout and is an enlarged version of the existing rocket we are using on the fourth stage. This fourth stage is a rocket developed by Alleghany Ballistic Laboratory which has been used on both the Thor-Able and the last Vanguard firing.

Mr. BASS. What are the dimensions of the Scout, Doctor?

Dr. SILVERSTEIN. It is about 67 feet high.

Mr. BASS. What is the diameter?

Dr. SILVERSTEIN. The diameter is about 3 feet at the first stage. It has about a 21 to 1 ratio, in other words, the height of it is 21 times its diameter.

Mr. BASS. Similar to the Vanguard?

Dr. SILVERSTEIN. In a way; yes. I think it is slimmer at the bottom than the Vanguard, but it is about the same height.

Mr. KARTH. That in effect is going to take over the job of what Juno II has previously done?

Dr. SILVERSTEIN. It is actually going to take over a number of the jobs. It will take over Juno II and some of the Thor-Able firings with a relatively inexpensive vehicle. The liquid fueled vehicles for example are costing us about $2½ million to $3 million. We are currently expecting that the Scout will cost about $600,000 or $700,000. We are not really sure now until we fire it, but it is in that order. It will be on the order of one-fifth of the cost of some of our liquid rockets.

Scout will reduce the cost and give us something that is versatile and can be launched from anywhere. It does not require as large a pad as used in the Thor or the other ballistic rockets. It can be launched from a portable pad, that is relatively inexpensive.

We hope it will have some of the early reliability that has characterized the solid rocket. The solid rocket in the past has reached a state of development earlier from the time of initial development until the time that it is really a useful vehicle than has the liquid rocket.

Mr. KARTH. The leadtime is considerably less?

Dr. SILVERSTEIN. Yes; to reach the same stage of development. This is another reason we have gone for it. One of the first steps

when the agency was formed, was to develop an inexpensive, easy-to-fire vehicle that would do the job that our smaller vehicles are doing now.

Mr. KARTH. How does the cost compare with the Juno II?

Dr. SILVERSTEIN. It is much less expensive. It is in the ratio I would say right now—you might want to check me on this Mr. Stoller but from one-fourth to one-fifth.

Mr. STOLLER. About that.

Dr. SILVERSTEIN. And the firing costs will be a great deal less. It takes a smaller crew to fire it.

Now Delta is actually not a new vehicle, but it is a modification of the Thor-Able. In working with the Thor-Able we found it had several weaknesses we wanted to correct. In the first place, the guidance system on it wasn't accurate enough. We took the guidance system that had been developed for originally the Titan missile, and put it in this vehicle. We didn't buy a new system, we took an existing system, that had already been tried out by the Air Force in one of their Thor-Ables that they used on the ballistic tests, and adapted the system to the Thor-Able.

We strengthened up the turntable at the top and made a few other minor modifications of the vehicle. This is the Delta vehicle. There are currently 12 of those in our program.

It is an interim vehicle, too. It is carried along in the program until it will be replaced by the Thor-Agena.

Now, what we are trying to do basically is to get our vehicle down into probably five major types to cover the ranges of sizes and missions we need to do. We need something that will put satellites on the order of 100 to 200 pounds into orbit. And this is the job for Scout. We want something we can put up 600 or 800 to 1,000 pounds with, and this is the job the Thor-Agena will be able to do.

We need something that we can put up 3,000 to 4,000 pounds in orbit, and 800 to 1,000 pounds to the Moon, and that is the assignment of the Atlas-Agena. Beyond that, the next step is Centaur, which will put approximately 1,800 pounds near the Moon, and some 7,000 to 8,000 pounds in orbit. Centaur has been a research and development vehicle in the sense that we are for the first time going into the hydrogen-oxygen technology. Saturn is wholly hydrogen-oxygen. The reason we use hydrogen-oxygen is because of its higher impulse, that is a higher amount of thrust per pound of fuel burned in the rocket. In other words, what we are trying to do is get a fuel that has the most energy in it per pound. And so in our Saturn development the upper stages of Saturn now are hydrogen-oxygen. The Centaur will be used as one stage of the Saturn vehicle.

The vehicle program, it serves as a background or basis for this scientific satellite program and our lunar program, and manned flight program. There are two things. To cut down the number of vehicles and to use engines and parts of vehicles over again so that as we accomplish a high level of development in the stage, we can continue to use it. I think it is a sound program in this respect.

Is that an adequate enough description of these vehicles?

Mr. TEAGUE. Yes.

Dr. SILVERSTEIN. Fine.

Now we go along to our firing program itself, outlined here, and you will see there is an S, a C, and an M here, in different colors. The M is meteorological, S the satellite, C is the communications satellites.

You see we have a firing here of a scientific satellite and here in this second quarter of 1961 we have two. On this page what we are showing are the vehicles which have either been—the vehicles and satellite payloads that have either been paid for with previous appropriations or which will be covered by the 1961 appropriation, and out here we show things in 1963 that will have to be started with the 1961 money because of the complicated payload. We have to plan ahead. We have prepared as you know, to present to you, at committee meeting, a plan ahead for 10 years in our thinking. It is absolutely necessary to plan in quite considerable detail for 5 years, because if you want to be some place at the end of 5 years, you have got to start now. The leadtimes in some of these systems are 5 years, in other systems it is 3½ years, in other systems they are 2 years.

What we have done is to go through enough of the engineering treatment of these various areas so that we predicted the leadtimes and the types of things we are aiming for and when to start them.

Mr. BASS. Doctor, what are the penciled numbers in the upper right-hand corner?

Dr. SILVERSTEIN. I was going to continue now. What I was going to say is that is a general layout of the facts in the satellite mission. I am prepared to associate with each of these numbers to discuss with you the actual flight, the kind of instruments that we will fly on this mission, and what we are trying to learn on these missions.

I can either go through this, and it will be a rather long discussion, one at a time or I can prepare for you a statement which will include this information and which you will be able to put your finger on any of these firings and say "This is what it is for."

Mr. TEAGUE. What do you think?

Dr. SILVERSTEIN. Or I might go through a few for you. I will do as you please.

Mr. TEAGUE. As far as I am concerned, if you say it here now, I won't remember all of it. If you give it to us in writing, we can read it on the floor. I can spend the night before going through it and studying it; it will qualify me better than going through a long series now.

Mr. BASS. I agree.

Dr. SILVERSTEIN. Fine. What we will do is present for you a discussion of each of these vehicles.

(The information can be found at the end of subcommittee No. 2 hearing of January 19, 1960.)

Mr. TEAGUE. Let me ask you this: anything in here that is sensitive, or that should be classified, you had better caution us.

Dr. SILVERSTEIN. I think what we will do will be, I think that the material we will have, let me say, and can present to you, can be unclassified, and those materials that are classified I think can be left out in that presentation.

Mr. TEAGUE. OK.

Dr. SILVERSTEIN. Most of our program is unclassified. The statutory requirement almost requests the material be disseminated as widely as possible. The only thing that is classified really are the characteristics of the boosters that are associated with the military program. And this we must hold, because it is tied in with the military program.

Now, let me go ahead, then, and indicate some more of our program here on the second chart.

This I have indicated as an earth satellite program. Here this is a lunar and planetary program, different because in one case we have a program of bodies that are orbiting the earth at different altitudes, perhaps, along different inclinations with respect to the equator. In some cases we fire due east, others we fire inclined to the south, inclined to the north, and in many of our programs we will be firing from our Pacific missile range instead of the Atlantic missile range, to get what we call polar orbits, where we fire due north and south, that fly basically over the poles.

Now this program is different because we don't do orbits of the Earth, but rather a firing toward the Moon and out deeper into space. You can see here that we have indicated firings here associated with our lunar and planetary missions.

The first of them is to be quite soon, indicated here interplanetary and it involves the use of the Thor-Able vehicle, with a payload to investigate some of the properties of far outer space, and even more particularly we want to get a technical evaluation of the communications from deep space. We hope this vehicle will go well out into space, and I am talking now on the order of 50 million miles, which is our hope.

It is being designed to do this. Whether we achieve it or not, of course is always a question. You set a goal and design for it, and then you do the best you can from then on.

But what we want to find out is what does it take to communicate with these distances, because in our later program we are going to be attempting to communicate with larger distances than this in the planetary work. That will be one of the principal functions of this test.

Now, we have shown here in the next date of interest in the first quarter of fiscal year 1961, and the second quarter, two Atlas-Able firings. You recall in the past year we made two unsuccessful attempts with this vehicle to orbit the Moon. We haven't given up yet. We have a beautiful payload, we think, and a payload that is well worth attempting to accomplish.

Mr. KARTH. If you are going to do that in the very near future, the Moon shot like we had on Thanksgiving Day; when is that going to be?

Dr. SILVERSTEIN. This is the shot here, and it is shown in the first quarter of 1961.

Mr. KARTH. Aren't you going to do it in a couple of weeks or so?

Dr. SILVERSTEIN. No; that is this other firing here. That is not the same firing. This is a different one.

Mr. STOLLER. The payloads are the same.

Dr. SILVERSTEIN. Well, they are somewhat the same. Of course this payload of the Thor-Able is considerably lighter than the other payload. Atlas-Able payload is around 300 pounds, and the Thor-Able payload is 87 pounds.

Mr. BASS. Are those two lunar missions identical?

Dr. SILVERSTEIN. Basically identical. What we are trying to do here is to make the shot. In other words, it is a backup in a sense, because the payload we have developed here is a very good one. There is a possibility that one or two instruments will be changed from one payload to the next, if the first one is successful.

Mr. BASS. Even if the first one is successful?

Dr. SILVERSTEIN. If the first one is successful, we will change some of the instruments in the payload. You see the basic payload, the package, the power supply, the energy source, the calimetry and these things stay the same, but the sensitive instruments you have in the payload can be taken out and others put in as we are developing instruments for this purpose.

So that we will get, if this one is successful, we will get other things here.

The following program with the Atlas-Agena, with the first firing of these vehicles in the fourth quarter of 1961, followed by four firings in the following year. This is our heavy lunar program here. Here we will have payloads that will be substantial. The payload for these vehicles will be on the order of 700 to 800 pounds, and with very substantial payloads with many advanced features on them.

Mr. BASS. Are they designed to orbit the Moon or land on the Moon?

Dr. SILVERSTEIN. The primary interest is landing on the Moon at different speeds, actually. The first of them is designated as an impacter. We are designing it so that the program will be initiated by an experimental flight to check out all the instrumentation, the hardware, and this is the beginning of the program.

Now in 1963 we have two—this is fiscal 1963, actually calendar 1962, about August and October actually. There is a possibility for a Venus and a Mars firing. Here we are attempting to do it with the Centaur, because we can get payloads that are very substantial out to those distances with the vehicle. They are shown on here, interplanetary.

Now again I can go through the descriptions of these, and I will be glad to put into the record some discussion of the actual objectives of the firings and the kinds of instrumentation.

Mr. TEAGUE. That would help.

Dr. SILVERSTEIN. Fine. Go to the next chart.

Now the Project Mercury program (fig. 9, p. 132), which I think most of you are familiar with from many sources of information that exist on this project, this is our firing schedule and it includes firings with three vehicles.

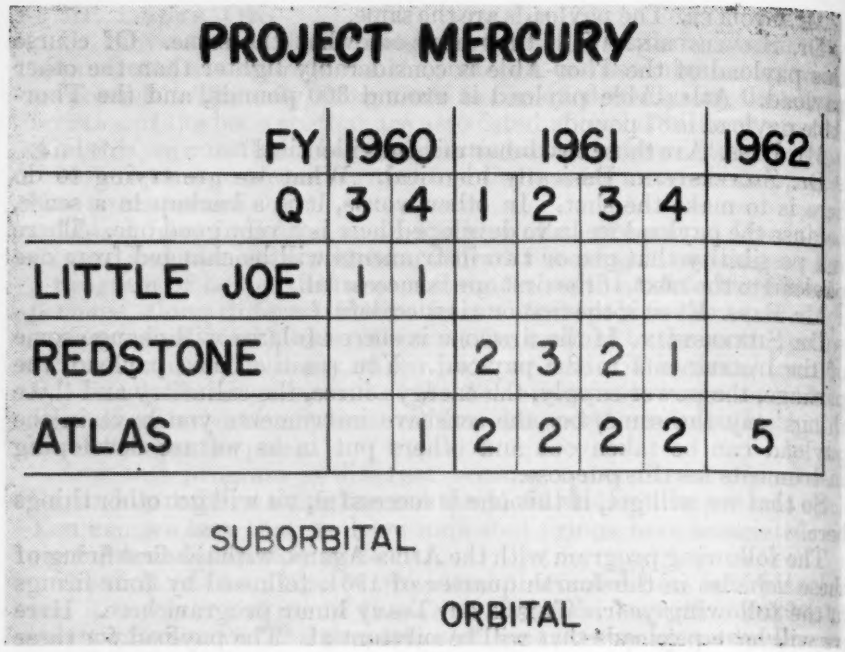

FIGURE 9

This firing here has already been accomplished in the first quarter of 1960. It is a Little Joe firing, a successful firing we just accomplished.

There is one more Little Joe firing. Then we go into our program with the Redstone. Here in general I will say about this program, what we are doing is going through a very intensive development program here aimed toward qualifying the vehicle that we are using in Mercury, the space craft, and the man, and to do this we recognize many aspects of this whole system that needs to be qualified. For example, we have to make sure before we put the man in the capsule that the methods that we have designed for controlling and guiding this capsule are going to work. The same way before we put the man in, we have to make sure that the heat shield that we have on the front of this capsule can protect the man from the very, very high temperatures that are encountered in coming back through the atmosphere. To see that this heat shield is going to in fact stand up.

We have to know that the structure that man is in is strong enough to undergo the various loads he has to go through. We have to know when that capsule sits down in the water it is not going to sink. We have to know it is stable on the water, that the man can get out of the capsule. The complicated systems of instruments in it, we have to know are going to be operative.

We have to know by animal flights whether or not in orbit for this period of time, there is something in the human system that won't be able to take it. The only way to find this out is to use this program. Through this program we are basically getting the qualification of every piece of it, leading up toward manned flight, which we are

hoping to have occur in this period sometime in calendar 1961, that is an orbital manned flight. And these vehicles here shown have been designed to accomplish these goals.

Now again, in this program we can give you a very thorough, detailed discussion of the missions, how we will go about this process of qualifying the thing.

Mr. TEAGUE. The more you give us, the better we can help you.

Dr. SILVERSTEIN. Fine. We can prepare that.

I thought it would be interesting to go through this, because most of the funds that you will find in the latter three of these four paragraphs we take up is associated with implementing this flight program.

Mr. TEAGUE. I hope this year we don't take up your authorization under a suspension like we did last year where each one of us got about 2 minutes. And of course you people have to go before an appropriations committee after you get through with us. If we can make a proper kind of record when we put this thing on the floor next week it will help you people a whole lot when you get before the appropriations committee.

Dr. SILVERSTEIN. Fine, we will provide that.

Mr. AMES. Will you make clear what parts you are treating?

Dr. SILVERSTEIN. The last three.

Mr. TEAGUE. All right, Doctor, shall we go back to page 110?

Dr. SILVERSTEIN. Yes, sir.

Mr. TEAGUE. Fiscal year 1959 was $1 million something, fiscal year 1960, $22 million something, fiscal year, 1962, $51 million something.

Mr. AMES. The reason for the $1 million item is there was a change for the budgeting procedure, for some of the money used for this kind of work in the previous budget were not set up in this form. The figure is not strictly suitable for comparison of $1 million. However the $22 million and the $51 are comparable figures. Last year they started the budget in this current form.

Dr. SILVERSTEIN. Let me explain first what this item actually includes within the scope of the whole item of the support of the NASA plant. It helps to clarify to look on page 110–B, where we can see that these funds are used in support of operations at all of our various locations for centers that are listed on the left on page 110–B.

You will see that at each of these centers these funds are used in support of the plant. Now those of you who have visited our plants, I think I can explain quite clearly to you the kind of operations that go on, and why they need support.

In our salaries and expenses support we provide salaries for the people at these plants.

In this account we provide the so-called DO–7, O–8, and O–9 moneys that keep the plant running, the O–7 being the professional services to provide these people, for example if they have to have a piece of equipment, a special research equipment built for them on the outside, they enter into contract with somebody based on drawings they create with their staff to develop it.

If they have to buy a piece of equipment such as an oscilloscope, a Geiger counter, or whatever the equipment might be, they have to have funds to purchase it. The maintenance of the plant from the standpoint of such things as window washing, purchased outside, any

items or repair or maintenance that are contracted for all come under this same account.

These items we have listed here are based on experience first, and secondly, based on the changing situation that exists right now. Now the experience that we have had in the past accounts for the base number. The increase is associated with two things. One, this difference between $22 million and the $51 million, between 1960 and 1961, if you will look down the list of locations you will find down in NASA, Huntsville listed for the first time in 1961, an item of some $18 million in support of this plant.

This accounts as you can see for an increase from $22,684,000 which is shown in 1960, up to about $41½ million, accounting for about all but $10 million of the increase between 1960 and 1961. As you all know NASA will maintain Huntsville operation after or during fiscal 1961, after July 16, and these funds are for that purpose.

The other part of the increase, some $10 million, is due to the fact that currently in all of our centers we are preparing to handle this space job that we have and increasing size of the space program by some reorientation of the program areas. I don't know whether many of you have been to our centers, our research centers, say over a period of 3 years, 3 years ago and now. You will see a major change in the direction of the work. When this happens, and it requires very careful planning by the research center directors—I lived through this experience for a number of years and know what it is to change over a plant from one type of activity to another, new equipment, special equipment, new resources are required to enable you to shift the gears and to utilize the people properly in the new program.

Largely, the additional $10 million is associated with these items.

There are some particular increases. I think the analysis by objects of expenditure at the bottom helps to clear up in a bit more detail the kinds of things that are included in support of the plant, and if we examine those you will see transportation of things, you will note there is an item of increase here of some $2½ million between 1960 and 1961 for the transportation of things.

Mr. TEAGUE. Before you leave that other part, what is your western office, your PMRO office and AMRO office?

Dr. SILVERSTEIN. The western office of our organization is an office that has been set up in Los Angeles to carry on for us on the west coast for some of the procurement activities that can be handled more expeditiously there because some of our contractors are located in that area. It enables us to make contacts with the industry which is highly centered in that area, with technical people who are stationed at the center.

It enables us to locate people there who are following some of our development programs through the plants that are operating there, and I will give you an example. We have several men located there who are technical people following the Centaur program. Now the Centaur program is being done by Convair on the west coast. It is very inconvenient to have these people riding back and forth all the time from the east coast to the west coast. It is a detailed job, so they are located there.

Mr. TEAGUE. Are the other offices the same?

Dr. SILVERSTEIN. No, we have an office for making contact with the AMR range at Canaveral. We have many projects going on the range. We need a man to represent us down there who sits down there and passes along to the range office our requirements.

Mr. KARTH. What is that salary, then, that $8,000?

Mr. AMES. No, there is no salary in here.

Dr. SILVERSTEIN. There is no salary in here. These are general supplies required to operate the offices.

Mr. TEAGUE. And PMRO?

Dr. SILVERSTEIN. PMRO is an area which we will—I mentioned in going through this program, we will be starting to fire from the west coast the PMR range. We will have to have an office there to transmit to the range there our requirements.

Mr. TEAGUE. Any question on that upper part?

Mr. BASS. No, I have none.

Mr. KARTH. I think he might, in his brief, explain the reason for the big jumps at Langley and Lewis Centers, which takes care of $6 million of the other $10 million.

Mr. AMES. I can comment here if you want me.

Dr. SILVERSTEIN. Yes, I will ask Mr. Ames, who is the Deputy to Mr. Abbott who is in charge of the headquarters operation of our advanced research programs, to manage these laboratories.

Mr. AMES. I would like to treat the items of Langley, Ames, Lewis and Flex Centers, these are the research centers. The increase in our 1961 requirements for the service, the contractual services, supplies, and equipment needed in supporting our research centers, results chiefly from the need for providing these laboratories with new specialized types of equipment required for research on space flight problems. This is a reorientation problem, where in the past we did work some on space, but we were pretty closely alined in aeronautics. We have been going through a transition period. Now this money is needed not for additional people but to give the people we have, we have been training the last several years, and reorienting them, to give them the equipment they need in order to conduct research.

Mr. TEAGUE. Gentlemen, this is Congressman Wolf, of Iowa.

Mr. WOLF. How do you do. I was involved in two debates and couldn't get here any sooner.

Mr. AMES. Some of the factors——

Mr. TEAGUE. This is Mr. Ames talking now.

Mr. KARTH. Sir, you might list some of the new equipment by names.

Mr. AMES. Yes, I have some items I will get to.

In general, our needs in plant support, as I said, are largely independent of the personnel levels, and reflect costs associated with accelerating our research programs in various supporting space objectives of NASA, and to a certain extent the military. We do research and support for both organizations.

Some of the factors affecting those proposed levels of expenditure here are high initial tooling-up costs in these advanced research areas, and here I want to identify them. They are materials—the application of materials for space vehicles, and advanced propulsion systems, such as nuclear and electrical powerplants. Hypersonic aerodynamics. We are now concerned with reentering the earth's

atmosphere not at orbital velocities but we are trying to get research leadtime in coming back to earth at higher velocity, at 27,000 feet per second. Our problems in higher speed range are much more difficult.

Dr. SILVERSTEIN. The losses you are talking about are those you achieve in coming back from the Moon.

Mr. AMES. Yes. This is an area now, we start research in this area now to give us leadtime for the vehicle that Dr. Silverstein is already planning and giving consideration to.

In addition, we are going out in the—we have the equipment we need to support our studies on control, guidance, and navigation in support of our space program.

Now, the whole nature of this work is such that the equipment we need is expensive and increasingly complex. These experimental research programs are much more complex than those we had before, because of the high velocities and higher temperatures and more performance we are trying to get out of our rockets.

In addition, we have a number of major new facilities with higher operating costs which are coming on the line in our centers this year.

One such activity is our Thunderbird missile at Lewis Research Center where Dr. Silverstein was for many years.

The Ames Research Center, we have a 3½ foot hypersonic wind tunnel. The temperature gets so hot we have to cool that nozzle with helium.

At Langley, we have a 7-foot thermal structural tunnel, where we are trying to create on the ground temperature and pressure environments these vehicles will have in space, so we can have research and design to bring the state of the art up to a point where we can get reasonable engineering solutions for these vehicles.

Lastly, we do have a large backlog of necessary repairs in attrition, replacement of obsolete equipment, and depleted stocks in many areas here.

I wanted to deal a little bit with each of these centers. I thought in a general way to give you a feeling for the kind of work each of the centers is primarily built.

In terms of research programs at Langley, down here in Virginia, we are expanding our research activities there and one of the items I mentioned, hypersonic flow, going to velocities higher than orbiting velocities. We are doing considerable work on high temperature materials and structure—this is the outer shell of the vehicle—to withstand conditions in space enviropment, the temperature conditions in coming back to the air's atmosphere, or going to the atmosphere of a distant planet.

In doing this research we find in many cases we have to do our research on our own instrumentation. We are measuring things that haven't been measured before. In many cases we devise our own instruments.

In addition, we require a good deal of electronic equipment in our guidance and navigational studies, and Langley, for many years, has been using our Wallop's range, because at times we have difficulty simulating environments on the ground, so we go out with rocket models in ballistic paths.

I will give you one example of a problem we are tackling. It is difficult at times to simulate in one experiment the true environment that a vehicle will experience, so by use of rocket models, we can fire out through the atmosphere and back in and reach the high temperatures and pressures that would be experienced .

Now, the important thing is an experiment of this sort is a very costly experiment. We don't do it very often, and we want to get all the information back we can. So we do—Mr. Stoller here spent a good deal of time in the Langley Instrument Research Division, developing the special instruments we use to make these measurements, high quality, scientific measurements.

A good part of our work at Langley goes into that area.

Now, in the past, the military services would provide us with the rocket-propelled models. They no longer do this, and part of the increase in budget here for Langley—you have $5.2 to $9 million, $2½ million approximately is just in buying rockets, so we can run these experiments. That is the cost for running these experiments.

Now, dealing with the work at Ames, which is the next item here, where we go from $3.6 million to $4 million, the increase is not as large as at Langley. Here our research program is going through rapid transition in the areas of space mechanics, fluodynamics at extreme speeds, stabilization control and guidance, where we have considered the man in the vehicle. We are already running on the ground simulating——

Mr. TEAGUE. Excuse me.

Off the record.

(Discussion off the record.)

Mr. TEAGUE. Back on the record.

Mr. AMES. We put a man in a cab that moves, that swivels a little bit. If you have been out to Ames, at their flight center, you can see it. We hook this up to analogs, where we can feed into this capsule the man is flying by control. It has the bench models of control systems that we will use in space.

We can feed into this cab some of the motions that man would experience in flying back, say from the Moon, or in flying back from a modification of Mercury, or a type of Mercury vehicle, a space ferry coming back from a space station.

We can see what the requirements are to make a control system and the man, and the inherent flight characteristics of this vehicle compatible. We put them altogether in a control loop.

So a good deal of our work at Ames is in the control gear we actually use on the ground, but we act as though we are flying it.

In the analogs and the other computing equipment that we use there in this pilot consideration of finding out what tasks a pilot can perform in a more sophisticated vehicle such as we look forward to in the future.

Then we go back to the wind tunnels, and our other studies of control in space, and try to push our research in that direction, so that ultimately the man and his flight equipment and his vehicle will be compatible, and be able to perform a mission precisely as we would like to have it.

This is the direction the Ames Center is going in.

Also at Ames, we have quite a few facilities where we are firing guns at very high velocities into wind tunnels, so we can simulate on the ground these high velocities I talked about.

There is no single facility within our know-how today that can give us in one experiment all the conditions we want to know. This is why we have different kinds of guns shooting in the wind tunnel.

We have a long range out there getting velocities up around 25,000 feet per second. We have prototype models of pilot research facilities where we can get 40,000 feet per second.

If we can do this on the ground, we can learn a whole lot more and provide basic materials for Dr. Silverstein's people, who will guide us more intelligently in our advanced vehicle programing.

Now, at the same time, at Langley and Ames we are working on lower leveling in the past, on low-speed aeronautical problems, on DTOL and STOL aircraft. This is all in this coming year.

Dr. SILVERSTEIN. Will you define the terms?

Mr. AMES. DTOL is a vehicle that takes off and lands vertically. STOL is one that takes off steeply, but not vertically, and can land in a more compromised landing than the vertical landing.

The Army is particularly interested in this type of aircraft, and we are working quite closely with the transportation corporations in helping them come up with requirements that in the time period of their development will be within the state of the art.

Mr. TEAGUE. I wonder how that program got under NASA?

Mr. AMES. Well, the research part of it is under NASA. The Army, of course, will buy their vehicles as the Navy and the Air Force do.

But the old NACA practice which we are continuing here, is to keep a close ear to the ground, to see what the Army wants to try to do.

Usually, the services want to do something beyond the state of the art. We try to close the breach.

Mr. TEAGUE. What is the status of that program? I saw the models down at Langley. What is the status of the DTOL and the STOL?

Mr. AMES. I can describe it best in the simple form by stating there are three basic areas. First, there is the test bed area where we have some of these vehicles flying today. If you look at them, they are very crude looking machines. They have no payload except a little research instrumentation, a pilot, and some fuel.

The purpose of these machines to test their program is to try in flight these various concepts to really see how they fly.

The key problem to the vehicles are twofold. One is: Will they have what we call flying qualities so a man can handle them adequately and perform a useful flight mission?

The second one is: Once we compromise this vehicle to make it fly the way a pilot would like to have it fly, being a nice flying vehicle, will it have any payload?

The helicopter and the DTOL and STOL type so far have not really had much payload, because you pay a penalty in structural weight for the gadgets that we need to make them fly this way.

So we are working on performance, and we are working on stability.

We have worked hand in glove with the Army in wringing out of these flying test beds all of the research information and engineering information that we could get. That is one phase. That program is still in its early flight stages.

The second phase I want to talk about is the phase where we are now working with the Army, helping them to arrive at a realistic requirement, or requirement for a vehicle that would be suitable for their use, which is realistic from the standpoint that a good aircraft engineering company could design and develop this in a reasonable time period at a reasonable cost.

One reason I think you want this in executive session, we just can't get in the next year or two the kind of vehicle the Army would like to really have. This leads us to the third stage.

We are doing rather general down-the-road research, in our centers, to see if we can't ultimately help the Army into the kind of vehicles they would really like to have to perform the Army mission. This is the third phase, this is a longer-range research program.

Is this clear enough, simple enough?

Mr. TEAGUE. Yes, sir.

Mr. AMES. We are doing some of this work at Langley and Ames. This falls into the category of objective research Mr. Abbot talked about, if you remember, before your whole committee, where we have a research program. But our objectives are definitely pointed towards getting useful vehicles for the Army, to provide the engineering information needed, so that the Army could have useful vehicles.

I wanted to speak to you on the work at Lewis. Every time I talk about Lewis I feel Dr. Silverstein can do a better job than I can.

But our increased funding at Lewis is predicated upon intensification and expansion of our research programs on electrical and nuclear rockets, electrical power generation, and basic material research related to propulsion.

This material research related to propulsion is pretty fundamental in getting the higher specific impulses that Dr. Silverstein mentioned.

Temperature is one of the basic limitations. If we can get temperatures in our reactors, temperatures in our other rockets operating up higher than 3,000° to 4,000°, up around 5,000° or higher, there is a tremendous gain in performance.

If I'd thought of it, I would have brought a chart along to show what these gains are. But they are quite large, and they are quite worth going after.

Part of this is getting to understand better the materials we have at these temperatures, and in getting modifications and improvements in some of the alloys and in the application of the materials, once you get these better alloys.

So we are expanding our work in materials at Lewis.

Now, the facility at Lewis, which works on rocket systems, including nuclear facilities, is nearing completion. And a good part of our funding at Lewis is in buying equipment and buying the supplies and the instrumentation for Thunderbird.

A $2 million in our Lewis item here is simply in buying fuel, propellants. In the past we used to get propellants from the services, but now we are considered large and independent, and they said why should we give you $2 million. We are interested in it, you are more interested in it, and you foot the bill yourself.

There is another $2 million increase in the Lewis item here for that purpose.

We estimate at Lewis that we would need contracting authority to the extent of about a million dollars to fabricate experimental engine and engine component parts for research, not the kind of component that would fly, but the kind that you would dare to try in a research experiment.

This is not even in the advanced technology. This is even further down the road than the advanced engineering technology part of our program.

So this accounts for about 2 million on propellants and 1 million on the contractual for advance engine parts, and that takes a good part of the $3 million that we have there for Lewis.

Now, at our Flight Research Station, I am sure all of you are aware that most of our—our major program at Edwards is attributed to tooling up and operating costs associated with our first research flights of the X–15. It has honestly taken us longer to get that vehicle ready to fly for research purposes than we had hoped, and we are going to push hard in the remainder of fiscal year 1960 and 1961 to really take the cream off of that project, by achieving maximum altitude and maximum speed. Maximum speed will come first.

One of the major items of expense there is that when this airplane goes up to 50 miles, and is going to reenter, we are beyond the part of the atmosphere where the Weather Bureau can tell us what the conditions are, temperature and pressure and things of this sort.

In order to know what the pilot is going to experience, this is a pretty critical flight plan the pilot has, and in order to interpret the data once we get these measurements, we have a program where we fly an F–104 at high altitudes, 60,000 to 80,000 feet, then we launch rockets from this airplane sending sounding probes, probes that measure temperature and density and things of this sort, out into the region where this vehicle will be flying in a matter of 5 to 20 minutes.

After the vehicle has flown through this region, we fire these rockets from the 104, to get a check reading on the data, so we can interpret accurately the measurements we get.

These are fairly expensive rockets—the operation of this program. It adds $600,000 for our operations at Edwards.

In the past, we flew 104's and B–52's, we didn't get up into this region and we didn't need this kind of backup support. That accounts for about $600,000 in the flight center program, only going from 800 to 1 million a year. We are taking 400,000 of it approximately out of the level we had budgeted last year, partially because we have cut back on the other airplane research going on at Edwards.

Our primary program at Edwards for the next year or two is going to be the X–15. This is a rather general coverage here. I will be glad to go into any of the other parts in detail that you have questions on.

Mr. TEAGUE. Any questions?

Mr. WOLF. I wonder if you would be more specific on what kind of programs were cut back at Edwards.

Mr. AMES. We cut back at Edwards, quite frankly, the work on the F–105. In the old days, NACA, we would have measured the pressures, the performance of the inlets, the drag of those vehicles to the *n*th degree. We have documented our work, aeronautical work, in wind tunnels, on things of this sort.

We feel this cutback is justified simply because the Air Force is not going ahead heavily with the fighter program the way it used to. You know, we had the F–100, the F–101, the 102, the 3, the 4, the 5, and the 6, and they canceled the 8.

(Discussion off the record.)

Mr. AMES. We are ready at Edwards to support the Air Force when the B–70 flies. We think the phasing of the flight testing of the B–70 will be such that most of the cream will be off of the X–15.

We think we have what will logically fall in line to get research information, leading to further improvements of, say, the B–70, and to apply to our supersonic transport program in this country from the B–70 by putting our X–15 experienced people on that * * * which is about the time that airplane is due to fly.

Incidentally, I believe this is classified I am getting to on the B–70 airplane.

Mr. TEAGUE. I would suspect so.

Mr. AMES. I want to point out there seems to be a natural phasing between the X–15 and the B–70. The B–70 is the main punch in advanced aeronautics in this country today.

Mr. WOLF. This is kind of in between where we are now and the ultimate in a missile type weapon. Is that right?

Mr. AMES. That is right.

Mr. WOLF. Do we have anything in fighter aircraft between the X–15 and back to the 106?

Mr. AMES. No, we do not.

Mr. WOLF. No research is being done?

Mr. AMES. We have research in our centers, in wind tunnels. Our flight research at Edwards has been reduced to the point where we are flying F–104's. This is about the highest performance we get out of our fighters today.

We will work with the Air Force on the B–70 when it is flying. In about 1 year we will take on a B–58 program, to try to explore what we can learn from the B–58, which will apply to supersonic transports.

This seems to be a little premature to get into that at this stage.

Mr. TEAGUE. Aren't they going to do some satellite launching from B–58's?

Mr. AMES. We have no plans ourselves to do this. Our people have studied this, and it could be done.

* * * * * * *

Mr. TEAGUE. Do you people get into the nuclear end of the B–58? Isn't the B–58 the plane they are working on as far as the nuclear-powered planes are concerned? Isn't some work going on there with a nuclear-powered engine?

Mr. AMES. Not to my knowledge. They may have used it as a test bed.

Dr. SILVERSTEIN. Not as an airplane.

Mr. AMES. I don't think it is big enough and suitable for the powerplant for the nuclear power plant.

Mr. TEAGUE. Then it might be Convair is doing it, and I associated it with a B–58.

Dr. SILVERSTEIN. Convair has had a study contract in this area. They have done quite a bit of work in shielding, and have used their bomber, B–36, to do the work. I am not familiar with the B–58 project.

Mr. AMES. I want to make another comment as to the extension of the program. We cut back on flying the F–107; we thought we got all out of that we should. We asked the Navy for an F–4H and they will make one available to us. Then we will exploit that in flight research. Not the kind of tests the Navy and the contractor does, but in extension of our flight research experience to find how high a mach number that airplane is capable of going to.

We have one scheduled within a year to be a production airplane. We are continuing our work there but at a lower level. It will be concentrated on the B–58, the B–70, and the F–4H when they are available.

We are calling our shots in this area, so to speak.

Does this answer your question?

Mr. WOLF. I think so. I was wondering also on this point, is there anything in research being done that will make the X–15 a tactical aircraft that can take off from the ground like any others, or does it always have to be launched from underneath something?

Mr. AMES. I don't think it will be really suitable for that purpose.

Mr. WOLF. Of course, we don't expect to use it as a tactical aircraft.

Mr. AMES. No. We did a lot of research on the X–3, if you remember that airplane, called the Flying Stiletto, I believe.

If you look at the wings, and inlets of the F–104, you will find it shows a resemblance.

Now, the research we do on the 104, on the X–3, I should say, pardon me, not the 103—was directly applicable. Then Lockheed came along for the 104 requirement, to the 104. And they took—they made a useful military airplane out of that information.

I would say if we want an airplane to fly at a speed range of the X–15, you could do better writing a worthwhile military requirement, useful military requirement, taking the research information, and bringing the design up to date.

You see, the X–15 was compromised for military requirements, just to be rugged enough to stand the high temperatures and the high forces.

Military airplanes come out with lower load factors than the load factor we have in the research airplane, because we don't know what will happen when a man exceeds his temperature, and things of this sort.

We will define many of the areas where these problems are severe, by the X–15, and if they are not going to be severe, we can learn how to handle them by other means. You wouldn't want to penalize the tactical airplane with the weight and structural complexity of the X–15.

Mr. KARTH. Mr. Chairman.

Mr. TEAGUE. Joe.

Mr. KARTH. How much money are you spending in technology on the B–70?

Mr. AMES. I would have to make a guess, maybe go back to check.

Mr. KARTH. Just a rough guess.

Mr. AMES. Most of our work on the B–70 was in the time period from 1955 through mid-1959. During that time period I would estimate NACA and some NASA work came in on it, it amounted to $5 million in house research.

Mr. KARTH. This program is kind of phasing out?

Mr. AMES. It is a program phasing out. We have gone beyond in our research. We have gone beyond the B–70. If you could visit Langley sometime we could show you a half a dozen configurations that would be much more efficient for this speed and altitude range we are talking about. But it would take you 8 years to engineer a design for this purpose.

What this really means is when we come along to design a supersonic transport, the new research information that we have, leading to two configurations, and the better engines that we would have by that time, based on our B–70 experience and our B–70 flight experience, would permit us to design supersonic transports which would be competitive with any other country's progress in that area.

We have gone beyond the stage of development of the B–70 in research.

I want to be careful here to caution you, this does not mean that the B–70 is obsolete, because if you take the research information, it takes you 5 to 8 years to even develop a new aircraft.

Mr. KARTH. Mr. Chairman, one question I have is on page 114 there, the O7 and other contractual services. This is kind of a nebulous bit of language to me. I would like to have some explanation on that.

What are these other contractual services? What do they include?

I see, of course, the big increase in that fiscal 1961 figure over fiscal 1960 figure is in the Huntsville area again.

Mr. AMES. Let's turn to page, I believe, 116 will answer that question.

Mr. KARTH. Repairs and alterations.

Dr. SILVERSTEIN. There are other structural services. It is made up of a number of items.

Mr. AMES. I have a list of repairs and alterations, a list of items under miscellaneous services, and items under services to other governmental agencies. It begins on 116, which covers the first item, major repairs and alterations.

We can turn a few more pages and I will find the other page number for you—we have to go through all the repairs and alterations. Then you get to page 123. You get to miscellaneous services. That is sketchily defined by the items, analysis of the items by category at the lower part of the page. In other words, I can go through each of these general areas and give you a clearer picture of what they are, if you would like.

Mr. KARTH. Briefly, I think you should do this, or in a brief, if you don't do it now.

Mr. AMES. Either way, whatever is your pleasure.

You get to an item on recurring equipment, way over on page 138. For example, if you turn over to—there is not too much of it here.

(Discussion off the record.)

Mr. KARTH. I am satisfied.

Mr. TEAGUE. Have you and Dr. Ames settled your point?

Mr. KARTH. I see how he has broken it down on page 116 and thereafter. I will take a look at those at my leisure.

Dr. SILVERSTEIN. These items are broken down in considerable detail, I think, through this whole section.

Mr. TEAGUE. Mr. Bass, do you have any questions?

Mr. BASS. I am looking at these green pages here, the second page, page 102, item 5.

Would you explain that, either Mr. Ames or Dr. Silverstein? You have a total program of $410 million for 1961, on page 101, by activities. And then you come out a couple hundred million dollars ahead here, largely as a result of this item 5.

Dr. SILVERSTEIN. These green sheets are not really an outline of the program on an authorization basis, but are included in this book at the request of the Bureau of the Budget from an expenditure basis actually, and discuss funding to be expected during the year, rather than commitments or obligations.

It is not an obligational picture here, but rather an actual fund expenditure so that what we have here are estimates of the actual funds, dollars to be expended during the year, and these are brought into alinement on the top of page 102, the item you mentioned, with this $213 million item, which will be funds expended in later years for which we are obligated during 1961.

Mr. BASS. I see.

Then am I correct, Doctor, in assuming that your expenditures, estimated expenditures for 1961 will be $410 million?

Dr. SILVERSTEIN. It will be $410 million of elements of the budget in 1961, plus accrual from previous years' obligations.

Mr. BASS. Where is that item?

Dr. SILVERSTEIN. The funding picture, I think, is given—you see in 1959, 1960 and 1961 here, so there is an accrual at the bottom of the page. Let's see. These are the actual accrual totals throughout the years you see. Actual funding amounts through the years 1959, 1960 and 1961.

In other words, these papers in green are a funding picture throughout, rather than an obligation picture. They are quite confusing because they have really no reference to the obligational picture.

We offer you true expenses in 1960 for obligations that you have made in 1959 and may accrue in 1961.

Mr. WOLF. Off the record.

(Discussion off the record.)

Mr. TEAGUE. Back on the record.

Anything else, Perk?

Mr. BASS. I will pass for the moment.

Mr. TEAGUE. Off the record.

(Discussion off the record.)

Mr. TEAGUE. Back on the record.

Suppose we discuss the Mercury projects for a little while. That is our biggest item.

Mr. BASS. I had just one other general question here, Mr. Chairman.

Mr. TEAGUE. Go ahead.

Mr. BASS. Dr. Silverstein, looking on page 110 and page 110-A, I gather that those subparagraphs "A" through "G" really summarize in general terms the reasons for the increases for these appropriations of 1961 over 1960.

If you had to put it in a few words there, it is right there.

Dr. SILVERSTEIN. This is the briefest statement that could be made, it may be a little too brief to be illuminating, but that is its purpose.

Mr. BASS. Thank you. That is all.

Mr. AMES. In fact, the primary purposes, sir, of my remarks are to try to develop these items a little bit.

Mr. BASS. I see that.

Dr. SILVERSTEIN. The man in space program discussion begins on page 164 of the book.

Mr. TEAGUE. Doctor, before we go into details of it, what is the status of it? Is it generally on time? I would guess from looking at your charts a while ago that maybe the objectives are a little farther ahead than we thought before.

Dr. SILVERSTEIN. I think, generally speaking, there has been no substitution of dates for Argus flights. There have been shifts in the program. We have lost a bit of time in different places.

My general feeling is for a program of this size and complexity, it has gone quite well. We are going to find out, I think as we go along, we are going to run into certain problems. We don't know what they are. We are trying in effect again to anticipate them.

We are carrying on a continuing research program in the area to enable us to define the problems we might run into, so we will be prepared to handle them when they come.

All in all, I would say the program is in very good shape.

Mr. TEAGUE. Well, I'm sure that you people have given more thought than we have to what will be the result if you try to put a man up and you don't get him back.

I saw a poll taken by a Member of Congress in California recently where he asked the question of his people, whether or not there should be a crash program, whether we should take a chance on a man's life to get ahead of Russia.

The answer was "No." I thought that was significant.

Mr. BASS. Doctor, if all goes reasonably well, when is the earliest date that you can expect to orbit a man on this program?

Dr. SILVERSTEIN. We would attempt an orbit sometime in early calendar 1961. But this requires that everything goes very well.

Mr. TEAGUE. This is an orbital flight?

Dr. SILVERSTEIN. This is an orbital flight. That has been our goal almost from the beginning. Whether we achieve it or not, I don't know.

I think that we are going to keep in mind the hazards of doing this job properly. We are going to do the carefulest job as we know how, to do it right.

As you know, all flights, new airplanes, new objects of any type, involve hazards.

Mr. BASS. But that is the earliest date we can reasonably expect this to happen?

Dr. SILVERSTEIN. This is for Argus flight. We would hope to have some of our ballistic flights of the Redstone manned before then.

Mr. BASS. Suborbital?

Dr. SILVERSTEIN. Suborbital.

Mr. TEAGUE. From the psychological standpoint and from the standpoint of a man being in space, your suborbital flights will be a man in space?

Dr. SILVERSTEIN. Definitely, except they won't be orbital.

Mr. BASS. When do you schedule your first suborbital manned space flight?

Dr. SILVERSTEIN. That will be in the second half of 1960.

Mr. WOLF. This year?

Dr. SILVERSTEIN. Do you mean Redstone?

Mr. BASS. Redstone.

Mr. WOLF. What seems to be the biggest nuts and bolts problem that is holding it back, or is there any one thing that you can put your finger on?

Dr. SILVERSTEIN. Let me say we have no basic major problems. We do have many, many problems associated with getting this hardware together quickly and putting it together, and it is a normal kind of engineering problem you have where you try to do a very complex job at the rate you are trying to move the program.

The program setup is two or three times faster than the normal rate for a comparable piece of equipment of similar capacity.

Mr. TEAGUE. In money, it is not a major problem. You have the money. It is just the case of getting all your engineering and whatnot together?

Dr. SILVERSTEIN. Well, we have in our supplemental this year, you will recall we have asked for some $12 million additional funds in the Mercury program, to make it possible to meet the schedule.

We will not be able to meet the schedule. We will slip without these funds.

The funding we have shown here is aimed again to provide for meeting these dates. There appears to be every possibility that we can do it, but it is a great complex operation, wonderfully complex. The ground system for it in itself is a tremendous complex program.

Mr. TEAGUE. More complex than you thought when you first started after it?

Dr. SILVERSTEIN. I would say that these things always become more complex as you get into them. That is the history of every development I have been associated with.

Mr. TEAGUE. I am one who wants that first flight to be a successful flight, and I don't care how long we wait to do it.

Mr. BASS. Even if we delay it for a long time.

Mr. TEAGUE. Even if we delay it for a long time.

I think an unsuccessful flight would have a tremendous impact on our whole program—I mean on the side that is not good.

Mr. DONLAN. This date Dr. Silverstein mentioned is tied in with that program he described, but it assumes that each of those flights leading up to this will be successful, and if the results indicate a need for further developmental flights, this we will do, of course.

Dr. SILVERSTEIN. I don't think most people in their minds can really grasp the problem of the extension of scope of this program, which carries our whole technology and science over mountains of time in fact, because we are talking about flying here at speeds some three to four times higher than anyone has ever gone before.

Historically, and for many years, and I watched it personally, we would try to get another 20 miles an hour out of an airplane flight or something, and then we began to take bigger steps with things like X–1, where we moved through the sound, and then up there the X-series of airplanes, the X–15, where we attempted to get 5,000 miles an hour.

But here we are talking about 18,000 miles an hour, and all the problems associated with it. It is a tremendous increase, and we are doing it very rapidly now.

We think we know the science. We built the background up for science by many years of work of a type that Mr. Ames was describing.

Currently we are building that same background up for taking the step in the future, as the flights go farther into space.

We are going to do the very best we can to make it successful.

Mr. DONLAN. I wonder if I could comment on one of your earlier remarks, Mr. Chairman, about what relationship the airplanes, aerodynamics in general have to this space business.

Mercury is a good example of this. We have run into more aerodynamic problems in getting a vehicle into orbit and back than we have ever run into before, because we cover the complete gantlet of the speed range, not only in one direction, but in the reverse direction, too, because the capsule goes out one way and comes back another, with or without a booster connected to it.

This has raised a whole gantlet of aerodynamic problems that the centers have had to turn their research tools over to help us solve.

So in the end, once you get back into the atmosphere, you have an aerodynamics problem in every sense the same as we had with aircraft.

Mr. AMES. Ten years ago, a man had only flown 850 miles an hour. Now, we are talking about 18,000. It isn't just a matter of pushing a button and getting there, as you know.

Mr. TEAGUE. No, I know. And it is so hard for at least this layman to conceive of all that has been accomplished. I have reached a point that any time I hear somebody say something can't be done, I look at him about four times.

I have gotten to the point where nothing surprises me any more. I think you scientific people will eventually do it.

Suppose we adjourn until 10 o'clock in the morning and in the meantime I hope to do some homework on this tonight.

(Whereupon, at 3:43 p.m., the subcommittee adjourned, to reconvene at 10 a.m., Friday, February 19, 1960.)

[EXECUTIVE SESSION]

1961 NASA AUTHORIZATION

FRIDAY, FEBRUARY 19, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE NO. 2,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 10:15 a.m., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. Doctor, I got on with my homework last night and I don't particularly have anything more.

If you people will prepare the things we have asked you for, that is.

Dr. SILVERSTEIN. We have already started a mechanism to get them to you.

Mr. TEAGUE. I had started to call you this morning. I would rather give you your time to work on that than to stay here.

Dr. SILVERSTEIN. Fine. We, as I say, had a meeting last night and this morning to start the system rolling to produce the material you asked for.

Mr. TEAGUE. If you will just try to remember, here we are going to be talking to people who know little about this, and we require information that to you is just nothing. We need to spell this out from A, B, C.

Mr. WOLF. You can anticipate the questions and obviously you know, because of the great controversy there is now, that there are going to be lots of questions about where the money is going and why. If you could somehow anticipate these questions that are going to come——

Mr. TEAGUE. Yes; and you made a very good point yesterday of the fact that this missile is another step in the road we are taking, that yes, we are going to get rid of this vehicle, but this other one is the one that is going to improve it and take its place. That is the kind of thing that means a whole lot over there on the floor.

Dr. SILVERSTEIN. Would it be helpful to have a document that might be arranged with a question and answer treatment?

Mr. TEAGUE. Yes, it would.

I asked Mr. Yeager last night, Doctor, to check back through the record. I asked him to check with the Appropriations Committee to see if there were any points we haven't covered that they raised questions about.

Mr. YEAGER. I have done that as much as I could in the time available, and there didn't seem to be any particular area with the possible exception of salaries and job allocations, locations for supergrades

and that type of thing; which, of course, was not in our part of the budget.

Mr. TEAGUE. While I think about it, will each one of you give us a biography so we can put it in the record?

I am sure you all have a prepared biography, so we can talk about what your background is.

(The information requested is as follows:)

ABE SILVERSTEIN, DIRECTOR OF SPACE FLIGHT PROGRAMS

Abe Silverstein is Director of Space Flight Programs at NASA headquarters in Washington, D.C. Before the NASA was established on October 1, 1958, he was Associate Director of the Lewis Flight Propulsion Laboratory, Cleveland, Ohio, a research center of the National Advisory Committee for Aeronautics, which formed the nucleus of the NASA.

Silverstein directs those NASA programs charged with mission planning, payload design and development, and inflight research and operation. Development programs under his direction include space probes and manned and unmanned satellite systems.

Silverstein is a native of Terre Haute, Ind., where he attended local grammar and high schools. He earned a bachelor of science in mechanical engineering degree in 1929, and a mechanical engineering professional degree in 1934 from Rose Polytechnic Institute. He was awarded an honorary doctorate by Case Institute of Technology in 1958.

Silverstein joined the National Advisory Committee for Aeronautics in 1929, and soon after helped design the full-scale wind tunnel at the Langley Aeronautical Laboratory. He later was placed in charge of this facility, and directed research which increased the high-speed performance of most of the combat aircraft of World War II. This work was recognized as a major factor in gaining U.S. air superiority during the war.

In 1943, he was transfered to the Lewis Laboratory at Cleveland to select and train a staff which he directed in research at the altitude wind tunnel. These investigations led to significant improvements in both reciprocating and early turbojet aircraft engines. He also pioneered with large-scale ramjet engines, now used on certain missiles.

At the end of World War II, Silverstein was directing the work at several major research facilities at Lewis. He directed the erection of the $9 million NACA 8- by 6-foot supersonic wind tunnel, first operated in 1949, and the $33 million NACA 10- by 10-foot supersonic wind tunnel, completed in 1956. These facilities, the largest wind tunnels of their kind in the world, have greatly accelerated the development of supersonic aircraft. In 1952, he was appointed Associate Director of the Lewis Laboratory, a post he held until he was named to the headquarters staff of the NASA.

Silverstein was a member of several NACA committees and subcommittees including Committee on Aerodynamics, 1946–47; Subcommittee on Self-Propelled Guided Missiles, 1945–47; Subcommittee on Internal Flow, 1947; Subcommittee on High-Speed Aerodynamics, 1945–57; Committee on Powerplants for Aircraft, 1951–57; and the Special Committee on Spact Technology, 1958.

He served as chairman of the Cleveland section of the Institute of Aeronautical Sciences, 1946–47. He was a member of the Committee on Arrangements for the Joint Meeting of the Institute of the Aeronautical Sciences and the Royal Aeronautical Society, held in New York City in 1949. The Assistant Secretary of Defense for Research and Development appointed him a member of the Technical Advisory Panel on Aeronautics for the year 1955, and Chairman of the Ad Hoc Working Group on Rockets for 1956. He was a member of the Scientific Advisory Board of the Chief of Staff, U.S. Air Force for 1956 and 1957, and Chairman of the OASD Technical Advisory Panel on Aeronautics, Ad Hoc Group on Propulsion for Aircraft and Missiles. He was a member of the Assistant Secretary of Defense's steering group of the Advisory Panel on Aeronautics for 1958.

Silverstein was American representative to the joint meeting of the Institute of the Aeronautical Sciences and the Royal Aeronautical Society, in London, in 1947. He delivered the annual Wright Brothers lecture before the IAS in 1949.

He is a member of Tau Beta Pi, and a fellow of the Institute of the Aeronautical Sciences.

Silverstein, his wife Marion, and their three children live at 7205 Rollingwood Drive, Chevy Chase, Md.

Milton B. Ames, Jr., Deputy Director, Advanced Research Programs

Milton B. Ames, Jr., was appointed Deputy Director of Advanced Research Programs at NASA headquarters January 10, 1960. Previously he was Assistant Director of Research for Aerodynamics and Flight Mechanics.

Ames is a native of Norfolk, Va. He earned a bachelor of science degree in aeronautical engineering from Georgia Institute of Technology in 1936.

He joined the staff of the NACA in 1936 as an aeronautical research engineer at the Langley Aeronautical Laboratory. From 1941 to 1943 he was engineering assistant to the NACA Director at headquarters. For the next 3 years he was engineering assistant to the Chief of Military Research in Washington. In 1946 he was appointed Chief of the Aerodynamics Division and later became Chief of the Aerodynamics and Flight Mechanics Research Division when the NASA was established on October 1, 1958. He was promoted to Assistant Director of Research for Aerodynamics and Flight Mechanics May 12, 1959. During his career, he has specialized in research on aircraft wing flaps and design of airplane controls.

Ames is a fellow of the Institute of the Aeronautical Sciences, and is author of numerous technical publications.

Mr. and Mrs. Ames and their three children live in Fairfax County, Va.

Hjornevik Gets New NASA Post

Wesley L. Hjornevik, 33, has been named Deputy Director of Business Administration for the National Aeronautics and Space Administration.

A veteran of more than 10 years of Government service, Hjornevik has served as assistant to NASA Administrator T. Keith Glennan since the agency was formed on October 1, 1958.

Before that, he was assistant to the Under Secretary of the Department of Health, Education, and Welfare for a year and a half. That post followed an 8-year stint with U.S. Bureau of the Budget.

He is a graduate of North Dakota State College (class of 1949) where he majored in economics and was elected to Phi Kappa Phi, national honorary scholastic fraternity. Born in Minneapolis, he grew up in Fargo, N. Dak., where his parents, Mr. and Mrs. Simon K. Hjornevik still live.

During World War II he served as an infantry sergeant with the Army in Europe. His service decorations include a Bronze Star and a Purple Heart.

He and Mrs. Hjornevik have five children and live at 5930 Braddock Road, Alexandria, Va.

Morton J. Stoller, Chief, Satellite and Sounding Rockets Programs

Morton J. Stoller was appointed Chief of the Satellite and Sounding Rockets Program, in the Office of the Director for Space Flight Program at NASA headquarters. He is recognized as an authority on all phases of instrument research and development work.

Stoller is a native of New York. He earned a bachelor of science degree in electrical engineering from the College of the City of New York in 1938. He was awarded a master's degree in electrical engineering from the University of Virginia in 1952.

Stoller joined the National Advisory Committee for Aeronautics, the predecessor of the NASA, in 1939, as an eletrical engineer at the Langley Aeronautical Laboratory. In 1947 he was named Assistant Chief of the Instrument Research Division at Langley.

His research work has chiefly been concerned with instrumentation used to obtain data from pilotless aircraft. He has also performed research in telemetering and computing.

Stoller is a member of the American Institute of Electrical Engineers.

CHARLES J. DONLAN, ASSISTANT DIRECTOR, PROJECT MERCURY NASA SPACE TASK GROUP

Charles J. Donlan is Assistant Director of Project Mercury, the name selected for the National Aeronautics and Space Administration's program for putting a manned space capsule into a controlled orbit around the Earth, to successfully recover the satellite, and to investigate man's capacity for withstanding the environment of space. Project Mercury is being carried out by the NASA space task group, a team of highly skilled scientists with headquarters at the NASA Langley Research Center.

Donlan was assigned to the space task group in November 1958 and was appointed Assistant Director of Project Mercury in February 1959. Prior to his appointment to the space task group, Donlan was Technical Assistant to the Associate Director of the Langley Research Center—where he helped initiate, guide, and direct research in various fields, especially in the areas of aerodynamics, stability and control, and hydrodynamics.

Born July 15, 1916, in Lawrence, Mass., Donlan attended secondary schools in North Andover, Mass. He received a B.S. degree in aeronautical engineering from Massachusetts Institute of Technology in 1938 and has taken graduate courses under the auspices of the University of Virginia.

Shortly after his graduation from MIT, Donlan began his career in aeronautical research at Langley with the National Advisory Committee for Aeronautics (NACA), which on October 1, 1958, became the nucleus of the NASA. His first assignment at Langley was in the spin tunnel section of the stability research division, where he helped develop a spin design criterion for monoplanes. Later work in the stability analysis group resulted in his preparing one of the earlier technical papers dealing with application of wind-tunnel results to dynamic flight conditions. He became assistant head of the stability tunnel in 1941, working on numerous stability and control projects.

In 1943, Donlan was on loan to the full scale tunnel group to assist in carrying out a stability and control program for an Air Corps airplane undergoing development tests in that facility. The next year, he was selected as project engineer with responsibility for the design and construction of the high-speed 7 by 10 foot wind tunnel. From 1945 to 1951 he was engaged in research and development programs in general aerodynamics and stability and control in the two 7 by 10 foot wind tunnel facilities—serving as head of the high-speed 7 by 10 foot tunnel section and as assistant head of the 7 by 10 foot tunnels branch. In 1951 he was transferred for special assignment to the office of the Langley Chief of Research and 4 years later became Technical Assistant to the Langley Associate Director.

Donlan has authored or coauthored more than two dozen technical reports. He has delivered numerous talks and lectures and has represented the former NACA at various technical meetings, both in the United States and abroad. In 1955, he was delegate to a supersonic aircraft design conference held in Bedford, England. As chairman of a Department of Defense special technical committee, he visited aircraft establishments in England and France. He represented Langley on the NACA aerodynamic stability and control subcommittee and on the interlaboratory research airplanes panel.

Donlan is a member of Tau Beta Pi and is an associate fellow of the Institute of the Aeronautical Sciences. He is a member of the Engineers' Club of the Virginia Peninsula.

Donlan is married to the former Marguerite Phelan of North Andover, Mass., and has two sons.

Mr. YEAGER. There are a couple of things, Mr. Teague, I think might be useful to get in the record. In the authorization bill, section D is something that seems to be new. This involves research and development, where it says that appropriations up to $20,000 can be used for emergencies—on page three, section D, I think perhaps Dr. Silverstein or somebody could explain this section, why they think it is needed.

Do you have a copy?

Dr. SILVERSTEIN. I don't have a copy.

Mr. TEAGUE. I think that should be written down too, in very careful layman's language.

Mr. YEAGER. This is something new that was not in last year's authorization bill. We should have that in the record one way or another.

Mr. TEAGUE. Yes; I feel that is a good idea too.

Mr. WOLF. Has there ever been a really good paper prepared on why it is important to go into outer space? I mean either in Congress or somewhere else?

Mr. DONLAN. I think the Killian committee wrote a document on it.

Mr. WOLF. I am not interested in the Bible. I am interested in something that would take about 10 minutes.

Mr. YEAGER. That is right. The President's committee did, I think about the time Congress was considering setting up NASA in 1958——

Mr. WOLF. Has this ever been put in the Congressional Record?

Mr. DONLAN. I am sure it has. Just last week I was reading some of the hearings in one of these commodities; it was attached as an appendix to one of those.

Mr. WOLF. What I am thinking of is background information ahead of this appropriation. I am amazed, as I have traveled around this country, at the number of people who still think it is all foolishness; our penetration into space.

What I am looking for is something—I will put it in my own words, if I can get some background material on which to build this type of speech, but I would prefer if I could quote from men who have made a lifetime, or a great portion of it their work, and the vision they see, somehow to tie this down. It does become important if we spent half a billion dollars last year and more this year.

Mr. YEAGER. The witnesses indicated to me yesterday that if they had a cut this year like last year that it was really going to hurt them. I think it might be helpful if you could provide us with some idea of just what you think would happen if you get cut this year like you did last year.

Mr. WOLF. What this could do to hold the program back?

Mr. YEAGER. Yes.

Mr. WOLF. In relation to our program.

Mr. YEAGER. If you can indicate what is going to happen, how much it is going to slow it down and how and why and where.

(Information requested is on file with the committee.)

Mr. TEAGUE. Be sure that you get an explanation of this "D" in here. I am sure that will come up.

Dr. SILVERSTEIN. Yes.

Mr. AMES. That is the $20,000.

Mr. DONLAN. Which item is that?

Mr. AMES. Line 18, page "D."

(The information requested is as follows:)

STATEMENT ON EMERGENCY EXPENSES

Subsection (d) of H.R. 10246 provides a small contingency fund for the National Aeronautics and Space Administration. It states that "appropriations other than 'Construction and equipment' may be used, but not to exceed $20,000, for scientific consultations and any emergency or extraordinary expense upon the approval or authority of the Administrator and his determination shall be final and conclusive upon the accounting officers of the Government."

Under this provision NASA would be able to meet occasional needs for any type of minor small expenditure not otherwise covered by authoriaztion or appropriation statutes.

For example, consultation expenses and other expenses in connection with visiting scientists and governmental administrators of other governments or representatives of private scientific organiaztions.

Also, overseas representation allowances in connection with space activities in foreign countries.

Also, any other purpose which the Administrator found to be necessary or desirable.

The language of subsection (f) is substantially similar to provisions of law previously enacted for the benefit of the military departments and the Atomic Energy Commission. The terms "emergency" and "extraordinary" expense and the phrases "approval or authority of the Administrator" and "shall be final and conclusive upon the accounting officers of the Government" are all found in Department of Defense appropriation acts, creating similar funds for the military departments.

It should be pointed out that such unusual and unforeseen expenditures as are authorized by subsection (f) can be undertaken only with the approval or authority of the head of the agency.

Mr. TEAGUE. I have gone through the thing and I have no questions other than what was asked yesterday. We would much rather give you the time to work on the things they are going to prepare for us.

Mr. KARTH. That is fine with me, Mr. Chairman.

Mr. TEAGUE. This stuff will be printed, and what you are preparing will be put in there. It will be distributed then to all the other members of the committee. So keep that in mind as you prepare it.

Do you all have any questions of us?

Dr. SILVERSTEIN. I think not. I think I see quite clearly the type of material that is needed to defend us, and we are at work now to prepare it for you.

The other questions I mentioned to the staff executive here that we could get in touch with him and find out how some of the material might be prepared better, or get in touch with you folks.

Mr. TEAGUE. As you say, Doctor, you are in the technical end of this thing and we are in the political end. But if you read the President's budget this year, I think the second or third paragraph made quite a point emphasizing the cut on this program last year.

Mr. KARTH. I think the Doctor understands, Mr. Chairman, we have gone over these systems time and time again in our regular committee meetings. This is probably one of the reasons we don't have so many questions to ask, Doctor. It is a matter of putting it down in writing as to the manner in which you would think it would be best presentable to a bunch of people in the House who really don't know much about the missile program. This is what we would like you to do.

Dr. SILVERSTEIN. We will do the best we can to cooperate.

Mr. WOLF. May I ask a question, Doctor? It probably doesn't relate too much to this question, but as you say, you are a technician.

What procedure do you follow to gather together technical data that would be helpful to you? This I know is a long question. I don't expect you to have to take that much time—from the various agencies in the country that do work relating to your work?

Dr. SILVERSTEIN. This is a long question but I will see if I can summarize it.

We have pulled together in our headquarters organization and in our centers the technical people who are up to date on the techniques that are involved in this whole area of space and aeronautical research.

We have qualified people. These people are scientists in their own right, technical people in their own right, who are not only helping to create this field themselves, but are aware of the work that is going on because they are up to the minute people in the field.

To advise them, we have set up as a part of the NASA organization a series of committees—subcommittees, or committees actually—some 13 of them, aren't there?

Mr. AMES. Fourteen.

Dr. SILVERSTEIN. Fourteen. They consist of the experts in various fields that are related to our work in the country. They advise us.

We have access to all the universities through the university program we are carrying on in this field, the contracts with many of the universities where the people such as Van Allen are working right with us. Van Allen is under contract with us to provide instrumentation for some of our satellites—not only Van Allen, but practically all of the top scientific people in these various areas that we are working in.

They are a part of our team. We have set up special committees, such as a committee on lunar and interplanetary efforts, who are again in an advisory capacity for this particular program.

So that we are actully bringing together, with our technical and scientific teams, the top technical and scientific people in all the rest of the country in these various areas.

Mr. WOLF. Supposing I am kind of a theoretical scientist out here in a small college in Iowa, if you please, and I think I have got something real good. How would I approach you? How would I get in touch with your organization?

Dr. SILVERSTEIN. This is a common, every-day occurrence in our field. You would send a proposal of some sort—it might be a letter proposal, it might be a more formal proposal—to NASA, Washington, D.C., stating your idea in outline and requesting information on how to proceed with it or how to take action on it.

We would, on receipt of this, turn it over to the scientific or technical group in our headquarters staff who have cognizance of this area. They would thoroughly review the proposal to find out if it really had technical merit, whether similar work was already in progress somewhere else, and if so, whether it needed to be expanded to include this program—in other words, they would give it a thorough review.

If it were found to be meritorious, and useful in the program, we would probably ask the man who forwarded the idea to give us a definite proposal that can be evaluated, one including costs, time of completion, reporting practices, and so forth.

Mr. WOLF. This is where my question follows then: Do you have the ability to "fund" this program to a degree if you feel it has merit in your organization, or do you have to come back to Congress to do this?

Dr. SILVERSTEIN. We have funds provided in this budget under so-called contract funds to carry on general work in this field.

Now, if it is a specific project aimed say toward an instrument to be installed in a scientific satellite, or in a lunar probe or meteorological satellite, we would charge the costs of this proposal against that program because it would be applied to that program.

So we find these costs are defrayed both from the general area of advanced scientific studies, which is under "Support of plant" in our budget, or it could be funded from the particular program elements that are related to the proposal submitted.

Mr. STOLLER. Part of that funding is on your page 144.

Mr. AMES. Yes; and I wonder if I could address a remark to you on that, sir?

Mr. WOLF. Certainly.

Mr. AMES. If you look on 109, the second item from the top.

Mr. WOLF. 109?

Mr. AMES. On 109, you see "Research grants and contracts" on page 109. We had $3 million in that in 1959. Do you have the page?

Mr. WOLF. Yes.

Mr. AMES. $4.9 million in 1960. We are asking for $10 million this year.

Over on page 144 we break down the areas which we have attempted to cover in this work. Perhaps the question may certainly arise in your mind why do we want to increase it this much in this year? We found that by October of last year we had so many good proposals that seemed worthy of contract or grant we ran out of money.

All the proposals we have received since then we have either had to turn down or suggested they resubmit them to us next July.

Mr. WOLF. Which is an unfortunate thing, which is the sort of thing we can't afford right now.

Mr. AMES. This is right.

Dr. SILVERSTEIN. May I show you this document?

Mr. WOLF. Yes. You can see now why I am asking this question, because it seems to me the big problem we have had right along is the raw research.

Mr. AMES. This is right. These are in basic areas which we are not handling ourselves. It complements the work.

Dr. SILVERSTEIN. We might as well go off the record here.

Mr. WOLF. All right.

(Discussion off the record.)

Mr. YEAGER. What percentage of basic research, I know this is a hard thing to define, but in general what percentage of its basic research does NASA do inhouse?

Mr. AMES. Well, in this area of research of the four research centers, about 30 percent of our work there we classify as basic, and that would approximate say $28 million considering salaries, expenses, and support program.

I might be a little bit off, but it is from $28 million to $30 million, somewhere in that area.

Our outside research you can see in 1960, $4,950 million. The figure I gave you on the 30 percent is the same figure we gave the Bureau of the Budget recently. The remaining 70 percent of our inhouse research is applied research, specific research assistance, in Dr. Silverstein's group or the military services.

Mr. YEAGER. You say 30 percent?

Mr. AMES. Of the work is what we classify as basic.

Mr. YEAGER. This breaks down to $28 million?

Mr. AMES. $28 million; yes.

Mr. YEAGER. This increase then might help to still some of the criticism which is being leveled because NASA has not been contracting out a sufficient amount of basic research.

Mr. AMES. We have taken a very firm hand to make this contract work as basic as we could. Dr. Lloyd Wood heads up this project. He is dedicated to that task. When you look at this 30 percent I call basic in the center, if you apply the same general definition, Dr. Wood doesn't completely agree with me. He says there may not be that much basic inhouse. This is the figure we included in our study and we call this basic.

Mr. WOLF. Dr. Silverstein, the question I wanted to ask was, what sort of report do you require from these people? Obviously all raw research doesn't prove out successful, but how do you have any proof that they actually did the work?

What sort of a program do you have to establish that they did some actual work, either mental, physical, or used up cash resources?

Dr. SILVERSTEIN. As a part of the grant or contract requirement, they must report on their activity; in a research area you are never sure whether work will have a positive value. But negative results are also useful because it keeps you from having someone else carry on the work and try to do it over when it may not be worthwhile doing.

So that we do require as a part of the contract the submission of reports during and at the conclusion of the contract.

Mr. WOLF. That brings me to the next question. Perhaps these don't relate exactly what we are doing here, but they are relative to the whole program.

Dr. SILVERSTEIN. Yes.

Mr. WOLF. Is this basic research information made available free to the private contractors and organizations in this country? In other words, for aeronautical research of any kind that might be related here, do they get this without paying for it?

Dr. SILVERSTEIN. Yes, sir. These documents are part of public information and are published and made available generally to whomever may wish them.

Mr. WOLF. So this could very well be termed a subsidy to the giant aircraft corporations in effect, because it saves them from having to do the basic research themselves in their own plants?

Dr. SILVERSTEIN. It is an historic fact that many areas of basic research need to be supported by the Government and have always been supported by the Government.

Mr. WOLF. I am not critical of it. I just meant actually what it amounts to is a cash subsidy to these plants if they get the work done by this organization, the results made available to them without any cost to themselves, other than some library, and studying through to find the fact they are looking for.

Dr. SILVERSTEIN. Yes. If you tried to develop the information in each of the organizations that might need it, there would be a great repetition of costs in attempting to reach the same end point, whereas if the work is done in one place and published widely, then everyone has use of it.

Mr. WOLF. That was the line of questioning I had. I didn't want to detain you any longer, as you have other things to do. I am grateful for this explanation. Perhaps I could ask you one more question.

I know this has been asked before, but I would like to ask it again just for the record.

How about a small corporation, a small business, that wants to manufacture a product related to the space program? How does he get in touch with either you or someone else? What is his procedure?

Dr. SILVERSTEIN. His procedure will parallel the procedure that I mentioned earlier.

He will submit perhaps by letter or in person his idea, proposal——

Mr. WOLF. He doesn't have an idea. He has 100 men and a plant.

Mr. KARTH. He wants to bid on one of your contracts.

Dr. SILVERSTEIN. We have a small business office in our headquarters organization, which he can contact, where we list all our pending requirements.

Mr. WOLF. He has to demonstrate he has the equipment to produce a certain thing. Then you try to find some product to fit his capabilities?

Dr. SILVERSTEIN. That, or he would be included in the list of organizations that accept bid forms for different items. Most of our work is carried on competitively, either by competitive negotiation or competitive bid. He would be put on the list of those who could compete for the work.

Mr. WOLF. Most of these are done in subcontracts though, aren't they, the small corporations get theirs on a small subcontract from the major, not direct?

Dr. SILVERSTEIN. It happens both ways. Perhaps more as a subcontractor. For example, in the Mercury program, we start with the number of major contractors in the program, such as McDonnell, Western Electric, and others, these contracts then begin to branch out and you find by going into several layers of subcontracting that you end up with perhaps several thousand manufacturing organizations that are actually involved in the program in some way or other.

You have your major subcontractors, then your sub-subs, and the thing comes way down to a very broad base.

We have looked at this development in the area.

Mr. DONLAN. There are also direct contracts with small units. For instance, at Langley we have a number of very small outfits that are working on the project. For instance, we have a transfer trailer that carries the astronauts' equipment, say, from a hangar to a pad, that needs to be modified. This is a fairly small job, but a small outfit that can bid on this thing and do it without working through a major prime contractor, so it works both through subs working through major primes and small companies working directly as a contractor.

Mr. WOLF. I know this, that dealing with the Government is not quite as simple as it sounds on the surface. There are always little side problems that develop. That is what I was thinking of.

Mr. DONLAN. I believe there was a pamphlet prepared on this very subject at NASA headquarters, precisely for this purpose, of acquainting the small contractors with how to go about that.

Mr. WOLF. All right.

I want to ask you another question not on the record.

(Discussion off the record.)

(Whereupon, at 10:45 a'clock a.m., the subcommittee was adjourned.)

(Material requested by the subcommittee and subsequently supplied is as follows:)

GENERAL STATEMENT ON THE NASA SPACE FLIGHT PROGRAM

The urge to explore is innate in man. The Spanish conquistadors sailed in miserable little ships to America to ransack the corners of the strange new world they found there. Wealth was in their minds, but adventure and exploration stirred them into action. In Biblical days the Israelites worked their way from Egypt to the Promised Land. A thousand years ago South Sea Islanders traversed the Pacific in outrigger canoes. In modern times explorers have penetrated the remotest parts of the earth. In the last half century, the wonders of modern travel have caught up with the last frontiers on the surface of the earth. The mysteries of the out of way corners of darkest Africa, remote Tibet, and frigid Antarctica have been exposed to public view. Our globe seems to have shrunk and shriveled.

But, with remarkable suddenness in the last decade a new frontier has been opened. A new domain—outer space—awaits conquest by man. A world awaits expectantly that first flight when man will free himself from the earth, and open the way to the Moon and planets. Nothing can hold back this drive into space except the collapse of our civilization.

Space is an infinitely vast region, and its conquest will place severe demands on human capabilities and resources. To lift even light equipment a few hundred miles above the surface of the earth is expensive. The cost of sending man to the moon will be far greater. But mankind in its history has never let the cost of exploration deter him from the task at hand. Whole tribes have picked up their belongings, left their tribal lands, and migrated to distant regions. Alexander marched his army from Greece to Hindustan. Portugal staked royal revenues on explorations of the coast of Africa, and a Spanish queen pawned her royal jewels to finance the search for a new route to India. The burden of the costs of such ventures was often very great, in many cases perhaps relatively greater than the burden that will be imposed on countries like the United States by the exploration of space. If we do not choose to assume this burden, other countries assuredly will.

Why should we, the United States of America, want to explore space? Why should we not leave it to someone else to do? There are many answers. We seek knowledge. We seek the benefits of knowledge. We seek the practical applications of the new technology that will develop. We yield to the urge to explore that is an American heritage. We seek to extend the domain over which man may move. Our national pride will not permit us to sidestep the challenge of space that lies before us. Our practical sense assures us that if we do not meet the challenge, we face a future as a second-rate nation on this earth.

What is this knowledge that we seek and how can we get it? We wish to learn all we can about the earth and its atmosphere, and about the sun and its influence upon the earth. Probing even further into the very nature of existence, we seek to learn the nature and origins of the universe, including the origin of our own solar system. And most exciting of all, we seek the origin of life and its possible presence beyond the terrestrial sphere. These problems we can attack by means of sounding rockets, satellites, and space probes. These new tools of space flight provide us with the means of sending equipment into the high atmposphere of the earth and beyond to make measurements and observations that can never be made from the surface of the earth. Eventually they will carry man himself as scientific observer and explorer.

One cannot overestimate the importance of the sun to us. The ancients worshipped the sun, intuitively recognizing this importance. The sun grows the food we eat, and furnishes most of the energy that we use in our daily living, in commerce, and in industry. Were the output of energy from the sun to change even a fraction of a percent, the effect upon the earth and its inhabitants would be tremendous. The changes in weather could be disastrous to mankind. Fortunately, no such change in the total solar energy output has occurred throughout the history of man nor is any to be expected for eons and eons of time into the future. Nevertheless, such is the influence of the sun upon our weather, the seasons, climate, radio communications, our sources of energy and food, that

knowledge of sun-earth relationships is of interest and importance not only to the scientists but also to the practical man.

The fundamental nature and origins of the universe are the basis of our engineering achievements. An indispensable first step in advancing our engineering and technological capabilities is to search out these fundamental laws and the properties of matter in the universe, so that the engineer can make his inventions and creations. We are all familiar with the tremendous practical power our knowledge and familiarity with electricity and magnetism have given us. Everywhere about us in modern day civilization are seen the applications of this knowledge. Who is to say what similar practical advantages may arise if we are able to achieve a comparable understanding of the nature of gravity, for example? Thus, even though we may not be able to predict or foresee the specific applications that will grow out of our new knowledge about the nature and origins of the universe, nevertheless the possibilities are so tremendous that we cannot afford from a practical point of view to omit the research that is needed to open up the opportunities.

In this connection, our nearest cosmic neighbor, the moon, offers tremendous opportunities to the scientist. Having no atmosphere, the Moon retains on its surface the evidences of its origin and history back to its early beginnings billions of years ago. Unlike the Earth, Mars, and Venus, which have atmospheres that erode away the surface features in relatively short times geologically speaking, the Moon has preserved a scientific record that the research man may use to explore into the origin of the solar system. But, to read this record in nature's handwriting on the lunar surface, the scientist must send his equipment, or go himself, to the Moon.

Most exciting of all will be the search for the origins of physical life, and the search for its presence elsewhere in the solar system. Were we to discover forms of life on one of the planets, this would undoubtedly have tremendous philosophical impact upon the thinking of all mankind. It is quite likely that the forms of life that might be discovered on the planets will be different in some respects from those existing on the earth, because the atmospheres within which those life forms developed, and the ambient conditions on the parent planet will have been different from those on earth. Yet this in itself may be more important and rewarding than if life forms identical to those on earth are discovered. For through a study of the differences along with the similarities, we may be able to take tremendous steps forward in our search for an understanding of the phenomenon of physical life. In the long run these studies may well have the greatest practical import of all to mankind. For an understanding of the origin and basis of life cannot help but contribute to human longevity and well being.

Manned space flight is inevitable. It will be an even greater step forward than was the launching of the original artificial earth satellite. With its achievement, the domain of man will have been extended by a tremendous factor. Man will in time reach the Moon, there to explore and probe the mysteries of the origin of the solar system. He will traverse the vastnesses of space to the planets and there personally conduct the search for extraterrestrial life.

But what will be the practical returns on our investment in space research and exploration? What counterpart to the riches of the Indies will we find? Many of these returns we cannot even begin to visualize. Science reflects in a very real fashion the injunction: "Seek and ye shall find". Whenever man has probed into strange and unknown fields of science, the discoveries have always exceeded the expectations of our ignorant state of mind when we began the search. The scientist who watched the twitching frog legs never visualized our modern day electric lights. Roentgen, experimenting with electronstreams in evacuated tubes, did not foresee the discovery of X-rays. Columbus never foresaw New York City. But in every case great rewards accrued to the effort put forth.

Even though we must accept on faith that the many returns from space research and exploration will indeed repay over and over again the value of our investment, still we can foresee some practical applications. One of these lies in the field of meteorology. We are all too well aware of the variableness of weather, and the difficulty of predicting what it will be tomorrow, or the next day, or the next week. We may, however, be sure that the rocket and satellite explorations of our atmosphere and the Sun will produce additional knowledge about the weather that we may put to practical use. Already the observations from the

satellites launched into the radiation belt have revealed to us that there may be a very important connection between particles from the Sun, the Earth's radiation belt, and weather disturbances. The full story is not yet known, but the practical importance of obtaining the full story is clear.

With the knowledge we gain about the weather, we move forward in our ability to predict and cope with weather. It may well be too much to hope that we shall ever control the weather, but we can hope to modify portions of it. The satellite will some day provide the platform for observing the weather over large portions of the Earth on an almost continuous basis. No range of ground-based weather stations adequate to accomplish this would be practical.

We have read or heard of a second practical development that can be foreseen—the use of an artificial Earth satellite for communications. Large reflecting spheres in orbit can be used to transmit by reflection telecommunications over large spans of the Earth. Reflection of radio and radar waves by the Moon and by an inflated sphere has already been demonstrated. Work and time can be expected to give the world a system of artificial satellites that will permit communication between any two points on the Earth. This satellite system will in its time be an achievement comparable historically with the laying of the Atlantic cable.

The ships that ply the seas are still efficient workhorses to move the cargoes of commerce. They will continue to be so, even while men are flying their spaceships to the Moon and planets. And the ships of the ocean will still find themselves with navigational difficulties when the celestial bodies are hidden by clouds or fog. Artificial satellites offer a solution to this problem. Carrying radio beacons, they cannot be obscured by fog or cloud. Crossing the sky repeatedly, they will give to ships almost hourly opportunities for taking bearings. One can visualize a group of satellites that would leave no ship to wander blindly on its course.

Space flight is part of America's future destiny. It poses a challenge we cannot ignore. It appeals to our pioneering spirit. It challenges our leadership in science and exploration. It promises a wealth of return in knowledge and understanding. It promises practical applications that will far exceed in value the required investment. It will extend the scope of our thought and action far beyond the confines of our past history. It requires the faith and support of the country.

Scientific Satellite Program

FLIGHT SCHEDULE

The funds requested in the fiscal year 1961 budget for scientific satellites will provide for the continuation of long leadtime work already underway for satellites to be launched through December 1961, and for the initiation of work necessary for satellites to be launched in 1962 and 1963. Also included in this budget request are provisions for the acquisition, reduction, analysis, and interpretation of data from satellites launched already or to be in orbit during fiscal year 1961, and provisions for the continuance of scientific and technical studies and the development of advanced instrumentation necessary for future satellite experiments.

The following flight schedule lists the satellites under this program including the ones to be initiated under this budget. This schedule also shows the phasing of the various launch vehicles over this time period. The Juno II vehicles and payloads started in 1959 will be launched by midfiscal year 1961 and then the Delta vehicles will be used to launch somewhat larger satellites through midfiscal year 1962. These in turn will be followed by the more powerful Thor-Agena B and Atlas-Agena B vehicles in fiscal year 1963. The Scout vehicle, a four-stage solid propellant rocket, becomes operational in fiscal year 1961 and will be the principal vehicle used from then on for launching payloads up to 200 pounds into orbits up to 300 miles in altitude. The appearance of these three new vehicles for satellite launchings in place of modified military missiles marks the beginning of the availability of vehicles designed specifically for the launching of scientific satellite payloads of significant weight. Henceforth it will be possible to launch satellites of greater weight and to achieve more difficult orbits. This increased capability matches the need of keeping the scientific program proceeding at a level which is adequate to follow up on the discoveries made so far, and to perform further exploratory investigations to learn more about the mysteries of space.

Fiscal year

	1960		1961				1962	1963	Total
Quarters	3	4	1	2	3	4			
Juno II	1		1	2					4
Scouts		1	1	1	2		5	2	12
Delta				1	1		3		5
Thor-Agena B							1	1	2
Atlas-Agena B								2	2
Total									25

The scientific experiments under this budget are more complex in nature and larger in number than was possible previously. The most important reasons for this are that the space experiments to date have laid a foundation for the planning of more accurate and detailed experiments, and the greater payload capacity and performance of the Atlas-Agena and Thor-Agena booster vehicles permit the inclusion of more and heavier instruments in the payload.

The large volume of space to be studied, and the considerable variations of properties with altitude, latitude, and time that occur in this region, require many satellites launched into different orbits over a considerable period of time to carry out an effective research program. Scientifically, the ability to obtain a large number of measurements simultaneously is extremely important. Early space experiments have provided strong indications of many important relationships and mutual interactions existing in phenomena associated with the earth, interplanetary space, and the Sun. For instance, further studies of the energetic particles of the radiation belts will be much more valuable if accompanied simultaneously by determinations of the variations occurring in the Earth's magnetic field and observation of solar events such as storms, flares, and Sun spots.

Eight new satellites are planned under this budget for launching in 1962 and 1963. Four of these are quite large and require Atlas or Thor-Agena B boosters for launching. The remaining four, although considerably lighter in weight, are still heavier than any scientific satellite which NASA has yet launched. These four will be placed in orbit by Scout vehicles.

Superficially, the total of 25 scientific satellites from the last half of fiscal year 1960 through fiscal year 1963 seems to be quite large. However, an examination of the number of scientific areas to be explored, while remembering that the Juno payloads average less than 50 pounds, indicates that this is a very small program in view of the immensity and complexity of the task. Actually, no more than one major effort is made each year in any principal field of investigation. For instance, in one of the most important of these problems, the radiation belts around the Earth, only three satellites can be scheduled in these 3½ years with the major objective of investigating these recently discovered phenomena. Further, this schedule will be stretched out in time by any failures, which would require the assignment of later booster vehicles and payloads to a repetition of the same task.

The individual satellites to be initiated under this program will now be described, followed by a résumé of the satellites already underway.

BUDGET EXPLANATION

The heading "Advanced technical development" contains two items. The first of these, "Scientific and technical studies," includes theoretical work and laboratory work supporting the flight program. The theoretical work includes the theoretical studies and evaluations necessary for the planning of an experiment, the drawing of conclusions from the results of experiments, and the preparations of explanations or theories accounting for the observations of space phenomena. The laboratory work is designed to search for new approaches and objectives in space research, to assist in evaluating the results of space research, and to verify and extend the results and theories of space science. This budget requests an increase of $500,000 to a total of $2 million under this item. This is a very modest increase considering the magnitude of the problems in space science, and will permit the continuation of research and theoretical work already under-

way. It will also provide support for the interpretation of the increasing volume of space results and the attendant questions raised by each new discovery. Here, attention should be drawn to the fact that in the first half of this fiscal year, NASA has launched three satellites and that eleven more will have been launched by the end of fiscal year 1961.

This budget requests $6 million compared to an appropriation of $3,061,000 in fiscal year 1960 for the "Development of advanced instrumentation." These funds will support the development of the instrumentation necessary for meeting the scientific objectives of the experiments. Some common examples of instrumentation used in space research include optical and mass spectrometers, pressure gages, Geiger counters, electric field meters, ion probes, and magnetometers. In all cases, specialized equipment suited for satellite use must be developed from laboratory models or must be designed as completely new instruments. The approximate doubling of the funds supporting these activities to a total of $6 million is a very small increase when compared to the increase in total payload weight from several hundred pounds in fiscal year 1960 to over 4 tons for the payloads to be initiated under this budget.

Under the heading "Flight research program" five different vehicles are listed: Here it is apparent that the programed funding of the five Juno II's and one Thor-Able (Explorer VI satellite) has been completed. The Delta vehicles are not listed on this budget because they have been procured under a vehicle development program; $3 million is requested for partial funding of the two Atlas-Agena B vehicles, and another $3 million for two Thor-Agena B vehicles, to permit the starting of the long leadtime vehicle work necessary for launchings in 1962 and 1963. In addition to this $6 million for the partial funding of these four major vehicles, the sum of $3,500,000 is requested for the procurement of seven Scout vehicles. Three of these will be used in the NASA international program, and four will be used in the national space science program.

The final item "Satellite payloads," indicates an increase from $13,425,000 in fiscal year 1960 to $24,200,000 in this budget. This item has increased due to the necessity of providing support for the start of payload work for the considerably heavier and more complex payloads to be launched in 1962 and 1963 as well as providing for the continuation of payload work for the Delta and other satellites to be launched through fiscal year 1961. Here it must be emphasized that the complexity of a payload frequently increases faster than its weight, as larger payloads are used. Longer lead times, sometimes in excess of 2 years, are required. The work budgeted under this item includes: (1) Instrument construction and procurement; (2) payload design and assembly; (3) environmental testing of instruments and prototype payloads; (4) construction of power supplies and telemetry equipment; (5) data reception, recording, and reduction. When compared to the increase of 700 to 800 percent in the payload weights of this budget compared to the earlier ones, the increase of only 80 percent in payload funds can only indicate that this amount of $24,200,000 is already a minimum.

Thus, the total budget request for scientific satellites in this budget has increased to $41,700,000 from $23,813,000 in fiscal year 1960. This is indeed a small increase considering the large increase in payload weights and the expanding scientific research problems under attack. This budget must provide the necessary followup work on satellites already launched or to be launched during fiscal year 1960 as well as providing for the national space science program in fiscal year 1961 and later. It should be quite apparent that this budget represents a carefully calculated minimum request to furnish the United States a proper space research program, and that any reduction in these funds can be reflected only by a reduction in the U.S. program of space exploration.

DESCRIPTION OF SCIENTIFIC SATELLITES

The orbiting astronomical observatory satellite to be programed under this budget is a very important first-of-its-kind scientific experiment. It is intended to make astronomical observations from above the obscuring and blanketing effect of the Earth's atmosphere. The weight of instruments and stabilizing equipment for this satellite will be more than 2 tons. The Atlas-Agena B will be used as the launching vehicle.

Another Atlas-Agena B will be used to launch a payload of approximately 600 pounds into a highly elliptical orbit for detailed studies of the radiation belts, the Earth's magnetic field, and atmospheric and ionospheric phenomena from

pole to pole. The region to be studied will encompass the Earth from a distance of a few hundred miles to at least 60,000 miles.

Another satellite will contain pointing controls to direct spectroscopes and other satellite instrumentation in detailed studies of the Sun. Additional instruments will also be included to help determine the nature of the role the Sun plays in determining natural events upon the Earth. This satellite will be instrumented to follow up and to extend the results obtained from the exploratory solar spectroscopy satellite to be launched near the end of 1960. The weight of this payload will be at least 500 pounds.

Another satellite will be launched into a low altitude orbit extending over the North and South Poles for investigations of the upper atmosphere, the ionosphere, the Earth's magnetic field, the aurora, and radiation phenomena. These investigations will follow up on discoveries already made and will search for the relations existing among these various natural phenomena, with particular emphasis on the unique properties of the arctic and antarctic upper atmosphere.

It is planned to launch these four major satellites over an interval of time chosen to permit overlap of the useful life of the satellites. In this way, maximum benefit will be realized from the variety of investigations to be made and the different orbits to be used. This simultaneity of reporting should be extremely helpful in unraveling the many different interactions existing among geophysical phenomena, and in understanding better the influence exerted by the Sun in controlling or influencing conditions on Earth.

In addition to these four major satellites, seven of the much less expensive Scout vehicles are included in this request; three of these are intended for use in the NASA international program and the payloads will be built as a cooperative effort with the participating nations. The remaining four Scouts will be used to launch satellites averaging 150 pounds into specific orbits chosen for the scientific investigation of selected regions of the Earth's atmosphere and ionosphere. These NASA payloads will be designed to search for new discoveries with a major emphasis applied to the polar regions—areas so far not investigated by the scientific satellites of any nation.

Four remaining Juno II satellites are on the schedule for launching through the first half of fiscal year 1961.

One of these, with a payload weight of about 20 pounds, will continue our studies of the radiation belts. Even with this light payload, the orbit cannot be extended to high enough altitudes to insure that the entire depth of the belts can be reached. Two more of these satellites will be devoted to studies of the Earth's ionosphere. This interesting region controls the propagation of radio waves over the Earth's surface and, hence, is of great importance to radio communications. These two satellites are a start in a major program of investigation and study of this region.

The final Juno II satellite will contain instrumentation for the measurement of gamma rays from above the absorbing effects of the Earth's atmosphere. Scientists hope that the results from this experiment will contribute to a better understanding of one of the mysteries of modern science, the nature and origin of cosmic rays.

Five Delta-launched satellites follow the Juno ones. Each Delta satellite is instrumented to study a different facet of space science.

The first of these satellites will enable astronomers to make the first studies of the Sun without the interferences caused by the Earth's lower atmosphere. This satellite will contain pointing controls to automatically keep the scientific instruments pointed at the Sun. The results obtained by this exploratory experiment will provide the background for the design of the much heavier-payload Thor-Agena B satellite requested in this budget for the investigation of Sun-Earth relations.

The second Delta satellite will be directed at further investigations of the radiation belts around the Earth. The instrumentation for this satellite will be selected to continue the investigations and to pursue in detail important results obtained by the earlier Juno satellite.

Another Delta satellite will be the first satellite in the space science program directed to the study of the structure and related phenomena of the upper atmosphere. This experiment should provide valuable new data about this upper region of the atmosphere and the results will be used in designing the payload for the Scout satellite requested under this budget for investigations of the atmosphere with a strong emphasis upon the comparatively unknown arctic and antarctic regions.

The fourth Delta satellite will be used to obtain more exact information about the Earth itself rather than for studies of space. This satellite will be equipped with an automatic flashing light of high intensity. Very precise photographic tracking of this satellite will furnish data leading to a more exact knowledge of both the location of selected points upon the Earth's surface and the configuration of the Earth.

The fifth Delta satellite will be equipped with complex electronic instrumentation designed to study the upper portions of the ionosphere. This satellite will be an important "first" in the investigation of the ionosphere because it will obtain measurements not heretofore possible. Radio soundings of the lower portion of the ionosphere have been made from the ground for many years and much useful information has been obtained. The nature of the ionosphere and its effect upon radio waves prevents the use of this technique in obtaining information about the upper half of the ionosphere. This "Topside sounder satellite" will be designed to make these sounding measurements from above the main portion of the ionosphere. The information thus obtained, plus the results from the earlier ionospheric satellites and the sounding rocket program, should contribute materially to our understanding of the nature and phenomena of the ionosphere.

In addition to the seven Scout vehicles requested under this budget, five other Scout launchings are on the schedule through fiscal year 1961. Briefly, the payloads for these launches include one for micrometeorite studies, two for ionospheric studies, one for cosmic ray and energetic particles studies using photographic emulsions, and one payload as a possible backup of the Juno program. The ionospheric studies and the photographic emulsion experiment will be launched as very high altitude probes (over 5,000 miles) rather than as satellites. Also, the emulsion experiment will require recovery of the payload for processing and interpretation.

It is worthwhile to compare the eight new satellite payloads to be started under this budget with previous space science satellites. The average payload weight for the four Agena B satellites will be roughly 1,500 pounds. Thus, the average Agena B satellite will be about three times the total weight of all scientific satellite payloads launched by NASA during calendar year 1959. The average Scout payload will be about the same as the 142-pound Explorer VI, the heaviest scientific satellite launched by NASA to date.

Thus, while the same number of scientific satellite launchings are scheduled for fiscal years 1961 and 1962, the total weight and number of scientific instruments to be flown has increased tremendously from fiscal year 1959, due primarily to increased vehicle capabilities. This increased activity in scientific measurements is reflected in the greater amount requested for scientific payloads in this budget. This increased budget will support and continue work on satellites already underway for launching in 1960 and 1961 as well as providing for the initiation of work for satellites to be launched in 1962 and 1963.

Manned Space Flight

SUMMARY

Project Mercury represents this Nation's effort to launch and recover a manned satellite. The program's primary objective is to study man's capabilities in a space environment.

A manned satellite will be launched from Cape Canaveral, using an Atlas launching vehicle. After the satellite has circumnavigated the globe three times, at an altitude of 120 miles, it will be made to return to earth. Recovery will be made in the Atlantic Ocean.

Because the ultimate achievement of manned orbital flight will mark a tremendous step beyond the present limits of manned flight, the Mercury program must be based on a logical and methodical buildup of capabilities. This buildup includes a broad research and development program of wind tunnel and flight tests. Capsule design criteria were evolved in a rocket flight test program, using nonproduction capsule models that could be fabricated at low cost and at an early date.

The buildup in capability will be continued with McDonnell-produced capsules, as soon as they become available. A series of unmanned and manned ballistic flights will be made, using the Redstone booster. In these flights the capsule will be flight tested, and astronauts will be trained for the longer satellite missions.

Qualification flights at higher speeds will be made on Atlas-launched ballistic flights. The capsule will be subjected to all the forces and motions of satellite flight and reentry, without actually entering an earth orbit.

Following these flights, the Mercury capsule will be ready for its first orbital flight. Satellite flights will first be made with instrumented capsules; then a chimpanzee will be flown, and recovered; and when we are convinced that all systems are sufficiently reliable, the first manned orbital flight will be made.

Project Mercury is being carried out with the greatest possible speed and urgency; the flight program is tightly scheduled in order to meet all objectives at the earliest practicable date. The project has been awarded a DX priority rating, and thus carries a priority equal to that of our ballistic missile programs. In order to meet the Mercury flight schedule, a copy of which is attached to this document, additional funding in the amount of $107,750,000 will be required in fiscal year 1961.

The compressed time phasing of the project, between inception and scheduled flight, has required that research, development, engineering, manufacturing, test, and training, be undertaken simultaneously. Inevitably, under these conditions, costs are incurred that are not expected at the time of the budget submission. Thus, for example, the funds required for Project Mercury were underestimated at the inception of the program, and supplemental funds in the amount of $20,750,000 were requested in fiscal year 1959. The fiscal year 1960 budget estimates were prepared at a time when the project had just gotten started. Once again, the funds appropriated in 1960 were insufficient, and a supplemental budgetary request in the amount of $12,200,000 was submitted in order to avoid serious delays in the program.

We are now requesting $107,750,000 to carry the manned space flight program through fiscal year 1961. Project Mercury is nearly 1½ years old. Much of the research and development program has been completed, and firm budgetary estimates can now be made.

The funds requested for 1961 represent the minimum level of funding required to carry the program through this period. These requirements are based on a detailed cost analysis, not only by NASA, but also by the suppliers of the Mercury boosters and capsules.

We are firmly convinced that funding at a lower level than the requested $107,750,000 will result in a serious delay of the ultimate objective of Project Mercury—manned orbital flight.

PROJECT MERCURY

Our long-range plans for the exploration of space are based on the premise that man will actively participate in many of our space missions. These plans, therefore, strongly depend on the assumption that manned space flight is feasible, and that man will indeed be able to perform useful functions in space. Much of our future effort depends on the validity of this assumption, and it is therefore imperative that man's capabilities in space be determined as soon as possible.

Project Mercury was conceived, and is being carried out, in a manner that will attempt to achieve manned orbital flight at the earliest practicable date. Its primary objective is to determine man's capabilities in a space environment.

In the Mercury mission, a satellite capsule will be launched into a 120-mile orbit, using an Atlas booster. The capsule will be fitted with an escape system, designed to separate it from the Atlas in case of a booster malfunction. In a normal mission, the satellite will circle the globe three times; at the end of three orbits, the capsule's retrorockets will be fired to initiate its descent toward the atmosphere. During its flight within the atmosphere, it will be slowed down, by the drag of the air through which it flies, to a speed where the landing parachutes can safely be deployed. After a parachute landing in the Atlantic Ocean, the capsule will be picked up by recovery ships that are standing by.

The accomplishment of Project Mercury will mark a tremendous step forward; putting a man into space will immeasurably extend the frontiers of manned flight. The speed of flight will be increased by a factor of eight over present achievements, and the altitude by a factor of five; the environment encountered in space flight will be one that heretofore has not even been approached. The event will be of such importance that it cannot fail to earn worldwide acclaim for the technical skill of the nation accomplishing this difficult task.

RESEARCH AND DEVELOPMENT PROGRAM

Because the ultimate achievement of manned orbital flight will constitute a stretching of the existing state of the art, its accomplishment requires a logical and methodical buildup of capability. This buildup included broad scientific and engineering investigations, using a wide variety of technical equipment, to determine a suitable shape for the manned satellite capsule.

Following these investigations, a flight program was initiated to develop and qualify the various components of the capsule. A Mercury flight schedule is attached at the end of this document. The flight program included airplane drop tests, in which full-scale capsule models were dropped from large cargo aircraft at high altitude. The tests were used to develop a highly reliable parachute system, and to determine procedures to be used in the recovery operations. In other tests, capsule models were released from fighter aircraft at supersonic speeds, to develop and qualify the capsule's drogue parachute. The escape system was perfected by launching full-scale capsules with the escape rocket as the only means of propulsion.

Rocket-boosted flight tests were required to check the capsule and its components over a range of speeds and altitudes. A solid-propellant rocket booster, nicknamed Little Joe, was designed and fabricated especially for Project Mercury. This booster, which develops 2¼ million pounds of thrust at takeoff, was used on a number of occasions to further aid in the qualification of the all-important emergency escape system.

The validity of the Mercury design concept was demonstrated in the fall of 1959 during an Atlas-boosted capsule test, called Big Joe. In that test, a capsule was made to reenter the earth's atmosphere, after being accelerated to nearly orbital speed. The Big Joe capsule, which survived the scorching heat of reentry, was later recovered many hundreds of miles from Cape Canaveral.

To date, more than 100 wind tunnel tests of the Mercury capsule have been performed; and 122 capsule models have been dropped from airplanes in the parachute development program. The escape system has been tested three times in simulated off-the-pad abort maneuvers, and four more escape system tests were performed in connection with four successful Little Joe flights. A small monkey was carried along on two of the Little Joe flights, in an attempt to gain further physiological data on the effects of space flight. And, as mentioned earlier, a single Atlas-launched capsule flight has been made.

All flight tests to date were made with so-called "boilerplate capsules." These capsules simulate the shape and weight of the Mercury capsules, but do not contain many of the systems and subsystems that will be required for manned operation. Boilerplate capsules are of simple construction, utilizing heavy, welded sheet metal.

MERCURY CAPSULES

In January 1959, McDonnell Aircraft Corp. was selected as the prime contractor to design and construct the Mercury production capsules. The selection was based on an industrywide competition; 12 firms submitted proposals based on NASA specifications for the capsule. After a thorough evaluation of these proposals, a contract was awarded to McDonnell.

The Mercury capsule is by no means a simple device. It has been a major engineering task to design a satellite that can withstand the heat and forces of reentry, and yet is light enough to be boosted into orbit. All of the components of the satellite—the environmental system, the attitude control system, the communications system—constitute major developments of currently available equipment. The complexity of the device is perhaps best illustrated by the fact that 7 miles of electrical wiring are interwoven into the capsule, in order to control the many valves, rockets, explosive bolts, and electronic systems.

The compressed time-phasing of the project, between inception and scheduled flight, has required that research, development, design, and fabrication be undertaken simultaneously. Inevitably, under these conditions, experience has required that modifications to design, arrangement, and structure be made during the conduct of the program. To date, a large number of capsule changes have been made, as a result of potential trouble areas that have been uncovered in the research and development program; further changes were incorporated to insure the safety of the pilot.

A total of 24 capsules will be required for the various phases of the flight program. During February 1960, a number of capsules were nearing completion, and delivery of the first capsule was scheduled for March 1960.

QUALIFICATION FLIGHT TESTS

Immediately after delivery of the first capsules, a qualification flight test program will be initiated. In this program, the production capsules will be flown on successively more difficult missions, culminating with the design mission of orbital flight.

In the first tests, to be carried out in the first half of calendar year 1960, the escape sequence will be tested in a simulated off-the-pad abort flight, and in another Little Joe flight.

REDSTONE BALLISTIC FLIGHTS

Starting in about the middle of this year, an important series of ballistic flights will be started, using the Redstone booster.

The Redstone will carry the capsule to an altitude of 125 miles, and to a distance of 200 miles from Cape Canaveral. The flight will last 16½ minutes. During that time, the capsule will be accelerated to a speed of 4,000 miles per hour and will withstand g. forces as high as 6½ during exit, and 11 during reentry. A weightless time of 5½ minutes will be sustained.

Initially, the Redstone-boosted capsules will contain only instruments. Later on, a capsule containing a chimpanzee will be flown along the same trajectory, and, when all systems are sufficiently reliable, manned ballistic flights will be made. In these flights, man will be subjected to more than five times the period of weightlessness than had heretofore been possible. The experience gained by the astronaut in the operation of the capsule in these relatively short flights, will be exceedingly valuable as part of the training program for the later manned orbital flights.

ATLAS BALLISTIC FLIGHTS

Capsule qualification at speeds higher than those possible with the Redstone, will be carried out with the Atlas. The Atlas will launch the capsule along a series of ballistic trajectories before it is employed in the orbital mission. In these flights, the capsule will be subjected to the speeds, forces, and heating that will be encountered in orbital flight. All of the Atlas ballistic flights will be unmanned. The Atlas flight test program will start in the middle of this year.

ORBITAL FLIGHTS

After completion of the ballistic flight tests, the capsule and its launch vehicle will be ready for the first orbital flight. The altitude of the orbit will be 120 miles, and the speed 17,500 miles per hour. Each orbit will last 90 minutes. It is planned to keep the capsule aloft for three orbits, or 4½ hours.

The first time the capsule is sent into orbit, it will contain only instruments so that the functioning of all the equipment can be checked. Later on, a capsule containing an animal will be flown to check the life-support system, the biological instrumentation on board, and to determine the physiological effects of long-term exposure to weightless flight.

Only after successful instrumented and animal flights have been completed, will the first manned flight take place.

ADVANCED REENTRY CONFIGURATIONS

Project Mercury is only the first step in our long-range program for the manned exploration of space. Long-range goals in our program include manned landings on the Moon, and still later, on the planets. Manned flight around the Moon will be a prerequisite for a lunar landing.

The Mercury capsule is not suitable as a return vehicle for a lunar mission. Instead, a capsule capable of reentering the atmosphere at higher speeds will be required. Our studies also indicate that a lunar-return vehicle must be capable of generating some aerodynamic lift, in order to minimize the mid-course guidance requirements. Aerodynamic lift may also be applied to control the landing point upon return from a stellite or space mission.

During fiscal year 1961, it is planned to expend less than 1 percent of the funds requested for manned space flight in the area of advanced reentry configurations. In this connection, two major areas will be considered: the use

of lift to facilitate reentry from space, and guidance and control methods for piloted space flight. Extensive analyses will be made, and scale models of various configurations will be evaluated in wind tunnels. Flight simulators will be used to evaluate the pilot's capability to fly such vehicles.

PROGRAM COSTS

In fiscal year 1961, $107,750,000 will be required to carry out the manned space flight program.

These funds can be divided into the following categories:

1. Biological and human engineering studies, $2,090,000

This item includes: (*a*) Personnel equipment such as astronaut's pressure suits, and transfer equipment to remove the astronaut from the capsule in case of an emergency on the pad; (*b*) training and training aids, such as special purpose equipment in support of the centrifuge programs, and world-wide tracking network simulation equipment; and (*c*) tolerance studies, such as equipment required to train and handle the animals used in Project Mercury tests.

2. Mercury development program, $4,050,000

Included in this category are: (*a*) Models for wind tunnel and small-scale flight tests, and for impact, vibration, and hydrodynamic tests; (*b*) support equipment for air-drop parachute tests; (*c*) testing of escape rockets and other pyrotechnic devices; (*d*) testing of the capsule structure and of impact attenuation devices; (*e*) tests of the reaction jet system; and (*f*) development and qualification of the communications system.

3 and 4. Advanced reentry configuration, $800,000; manual and automatic guidance and control system for advanced reentry configuration, $200,000; total $1,000,000

These two items represent the funds required for studies leading toward the follow-on program to Project Mercury. Included are wind tunnel and structural tests, subsystems development, and inertial guidance systems development.

5. Major boosters, $25,650,000

This category includes (*a*) the completion of the funding for 8 Redstone boosters used in Mercury qualification and training flights; and (*b*) partial funding for 15 Atlases, used in the development, qualification, and orbital missions.

6. Mercury capsules, support equipment, and support services, $35,290,000

Included here are: (*a*) the procurement of 24 Mercury capsules including changes and revisions as dictated by the research and development program and by pilot safety considerations; (*b*) spare parts for the capsules; (*c*) ground support equipment to check out and monitor capsules at ABMA and Cape Canaveral; (*d*) capsule flight test support services; (*e*) training simulators used by astronauts and ground crews to develop operational procedures and experience; and (*f*) equipment and services to support the research and development program.

7. Tracking network operations and equipment, $24,670,000

This item includes: (*a*) research and development costs required for the implementation of the network, such as reactivation costs of the network ships, funds for the installation and modification of certain equipment, and consulting services; (*b*) network operation expenses, such as computing equipment services, maintenance and operations personnel training and services, transportation services and supplies and materials; and (*c*) special operations support by the Atlantic Missile Range, including special cabling, communications and circuitry services.

8. Recovery operations $15 million

Included in this category are all costs that will recur for each flight mission, such as: (*a*) Pre-flight trajectory calculations; (*b*) Air- and ship-borne data acquisition (*c*) data reduction and analysis services (*d*) operation of the mid-Atlantic and Indian Ocean tracking ships, (*e*) and the actual ship and aircraft operating expenses incurred in direct support of Mercury recovery operations following both Redstone and Atlas flights.

Mercury flight schedule

	Fiscal year 1959		Fiscal year 1960				Fiscal year 1961				Fiscal year 1962
Beach Abort	1	1	1	----	----	1	----	----	----	----	----------
Little Joe	----	----	1	3	1	1	----	----	----	----	----------
Mercury Redstone	----	----	----	----	----	----	2	3	2	1	----------
Mercury Atlas	----	----	1	----	----	1	2	2	2	2	5
	← Research and Development Capsules →						← McDonnell Capsules →				

Communications Satellite Program, Fiscal Year 1961

PROGRAM OBJECTIVES

One of the major objectives of the NASA is to establish the use of satellites for providing global communications. Such communications satellites can provide almost unlimited capacity for the instantaneous transmission of teletype, telephone, and television throughout the world. The capacity of present communications facilities will soon be exceeded and there does not now exist any wide-band width communications system capable of transoceanic television transmission. Communications satellites can provide this required capability and will also be able to satisfy the growing needs of scientific data transmission to appease the appetites of high-speed electronics computers which have revolutionized the rate of scientific progress. Not only can communications satellites satisfy these urgent needs but currently appear to provide an economically sound solution to the problem when compared with undersea cables, tropospheric scatter systems, or microwave links—none of which show the inherent promise of satellite systems.

Satellites which can be used to provide communications over large areas of the earth can be placed into two broad categories—the active repeater satellites and the passive satellites. The active repeater satellites contain electronics and an appropriate power source which permit a radio signal, sent from one point on the earth, to be received on board the satellite, amplified, and then retransmitted to a distant receiver. The other category, the passive satellite, is comprised of satellites which merely reflect back toward the earth radio signals originating on the earth.

Because of some rather immediate tactical needs, the DOD has embarked on a program to develop certain forms of the active repeater communications satellite. NASA is interested in establishing the technology necessary to the design of the more general communications satellites for civilian and commercial use. In the area of active repeater communications satellites, NASA is watching with interest and relying on the DOD programs to provide the early stages of development. NASA has established an active research and development program in the area of passive communications satellites. Our initial effort calls for the development of large inflatable spherical satellites and the investigation of this form of satellite as a communications medium.

FLIGHT SCHEDULE (by quarters)

	Calendar year 1960				Calendar year 1961				Calendar year 1962			
	1st	2d	3d	4th	1st	2d	3d	4th	1st	2d	3d	4th
Project Echo, single-sphere launchings	------	X	------	------	------	X	------	------	X	------	------	------
Multiple-sphere launchings	------	------	------	------	------	------	------	------	------	------	X	------

Flight research program—single-sphere launchings

To explore thoroughly the use of large inflatable sphere satellites for use as a communications medium, NASA has established the following flight research program. Three orbital launchings of a 100-foot diameter sphere will be conducted: one in the second quarter of calendar year 1960, one in the second quarter of calendar year 1961, and one in the first quarter of calendar year 1962. This series of experiments has been named Project Echo and is designed to develop the technology necessary to the establishment of durable structures in space and the evaluation of their use as communications satellites. The Project Echo No. 1 satellite will be a 100-foot diameter inflatable sphere, developed by the NASA Langley Research Center. It is constructed of mylar, a plastic, one-half thousandth of an inch thick, with a vapor-deposited coating of aluminum to provide reflectivity. The sphere weighs approximately 136 pounds and has 31,416 square feet of surface area. The satellite is folded into a container 26 inches in diameter and the container is evacuated to a low pressure. A subliming material (one that passes directly from a solid to a gaseous state) is placed into the sphere before packaging to provide for inflation of the sphere in the vacuum of space after it has been released from its container. When established in orbit, the sphere will be used to demonstrate the feasibility of using such spherical satellites for communications, and to perform the communications experiments described below.

Single-sphere ballistic launchings

To support the development of the 100-foot sphere, several ballistic launchings from Wallops Island have been scheduled. Two such tests have been performed at this time: the first was on October 28, 1959, and the second on January 16, 1960. A third launch is scheduled near the end of February 1960.

The first test revealed that the sphere ruptured and broke into several pieces. The second test suffered from a vehicle fault but the sphere was ejected. Information obtained from this second test indicates that the faults in the first test may have been corrected. In addition, inflation of the sphere in a large vacuum chamber indicates a satisfactory initial inflation process.

Flight research program, advanced design

Project Echo satellites Nos. 2 and 3 will be similar to No. 1 but utilizing more advanced design resulting from previous flights. These improvements may include rigidization and launching into polar orbits. Additional ballistic launch tests are planned for the development of Echo payloads No. 2 and No. 3.

Costs, single-sphere launchings

The costs for the Echo No. 1 payload development are a little less than $1,100,000. It is estimated that payload development and procurement costs for Echo Nos. 2 and 3 will be nearly the same as for No. 1 ($734,000 in fiscal year 1960 and an additional $300,000 in fiscal year 1961 for No. 2 and $1,100,000 in fiscal year 1961 for No. 3). It should be pointed out here that these costs are, for the most part, hardware costs. Since most of the development, engineering design, and testing is done within NASA, these costs do not reflect personnel and overhead expenses.

Flight research program, multiple-sphere launch and costs

To establish and maintain continuous communications, a number of satellites in orbit will be necessary in order that at least one is always in sight of the two stations desiring to communicate. Studies indicate if no effort is made to control the relative position of satellites, on the order of 26 spheres in a 3,000- to 4,000-mile orbit would be required to provide 99 percent availability. A launching of a multiple rigidized sphere payload, utilizing the booster capabilities of the Atlas Agena-B is planned for late in 1962. In order to meet such a schedule, funding must be made available by fiscal year 1961 to begin this development. The cost of the Agena-B payloads have been estimated to be $2,600,000 of which $1,450,000 will be required in fiscal year 1961.

Communications experiment

In order to evaluate the communications capabilities of satellites established during the flight program, NASA has instituted a program and is providing facilities to be used in communications research. Two primary facilities are under development: the JPL Goldstone facility on the west coast and the Bell Telephone Laboratories facility (development costs borne by Bell Laboratories)

at Holmdel, N.J., on the east coast. Special transmitters, receivers, antennas, and antenna-pointing equipment have been developed for these communications terminals. These stations will demonstrate the feasibility of satellite communications and in addition investigate radio frequency transmission characteristics, modulation techniques, and tracking techniques as well as determine the shape of the satellite in orbit.

These facilities as well as the Lincoln Laboratory Millstone radar, which will be used for tracking the satellite, will be used throughout the research and development phases of the NASA communications satellite program. Additional developments for these sites will be required to keep pace with the satellite developments.

Costs, ground support

Ground support requirements for the communications experiments will be approximately the same; namely, $1,296,000 in fiscal year 1960 and $1,300,000 in fiscal year 1961. Although facilities improvement costs will drop slightly, increased utilization of facilities will more than counteract this reduction.

Advanced technological development programs

To support the extensive communications satellite flight program described, a considerable number of research, development, and study programs have been initiated. These programs include computer techniques for data reduction, the influence of ultimate communications requirements on satellite systems, large spheres and other forms of passive satellites, rigidization techniques for space structures, propagation studies to determine radiofrequency characteristics of various structures, electrically steerable antenna arrays, scientific data transmission requirements, and stabilization systems for passive satellites. Equipment development in this area includes communications transmitter, digital antenna-pointing equipment, and radio beacons for inflatable space structures. Continued and expanding efforts to support the advanced flight program are required in over half of these areas. Such expansion is indicated in the increase of from $740,000 in fiscal year 1960 to $1,100,000 in fiscal year 1961 in the area of advanced technical development.

Deep space communications

In addition to the flight and supporting programs described previously, the NASA has begun research and development in deep space communications. Studies have been initiated to determine communications requirements for lunar and planetary programs. In addition, investigation of components, techniques, and systems are being undertaken. The area of deep space communications is extremely broad, covering many forms of data transmission, and it is in the early stages of growth. Considerable research will be required in order to better understand the problems which might be encountered in establishing reliable communications in these hitherto unexplored regions. The program reflected in the fiscal year 1960 and fiscal year 1961 budgets is pointed towards establishing research and developments that will lead the way to uncovering problems and afford solutions in deep space communications.

Sounding Rocket Program

A sounding rocket is a rocket that rises to a maximum altitude of no more than 4,000 miles (one Earth's radius) and then falls back to the earth. The primary use of sounding rockets is for the scientific exploration of the upper atmosphere, especially in the region extending from the maximum altitude attainable by balloons of about 20 miles to the minimum useful altitude of satellites of about 125 miles. Rockets are used to determine the nature, structure, and behavior of the atmosphere and its interactions with incident radiations and particles, particularly those from the sun; and to measure radiation arriving from other celestial bodies, from above the obscuring and distorting lower atmosphere, which handicaps all Earth-bound astronomers. In addition, sounding rockets are used for the extremely valuable purpose of testing equipment before use in the far more costly satellites and space probes, and they also furnish a relatively inexpensive method of performing certain specialized scientific experiments such as the recovery of film which records the passage of high energy particles at altitudes of several thousand miles. The relative

simplicity of the launching facilities required by sounding rockets is a distinct advantage, and launchings from the Arctic (Fort Churchill, Canada) and Australia, as well as from the NASA Wallops Island, Va., site, are planned to achieve better worldwide coverage.

The $8 million requested in the fiscal year 1961 budget for the sounding rocket program will provide for its continuation at about the level established during the International Geophysical Year and maintained in the NASA schedule for calendar year 1960. This level of 90 to 100 rockets per year will provide for the continuation of the planned research program in the scientific areas of atmospheric physics and astronomy, which each consume roughly one-third of the rockets; and in the areas of ionospheric physics, high-energy particles, and magnetic fields, which each consume about one-tenth of the rockets. This NASA space research program using sounding rockets is coordinated closely with the NASA scientific satellite and space probe research programs, and with the upper atmospheric research programs of other U.S. agencies, to form a unified national program of scientific space exploration.

The sounding rocket program costs are divided into advanced technical development and flight research program. Under the former category is included $500,000 in fiscal year 1961 for "scientific and technical studies", which is 30 percent less than the amount appropriated for this purpose in fiscal year 1960. Such studies include long-range theoretical and laboratory investigations of the probable nature of the upper atmosphere, are based on past measurements, and lead to future sounding rocket experiments. The actual "development of advanced instrumentation" for the conduct of such experiments will require $1,300,000 in fiscal year 1961, which is nearly 40 percent less than the fiscal year 1960 appropriation. It has been possible to reduce these two items because the initial development of experiments has been completed and the sounding rocket program has leveled off at a rate which should not require a major increase in the number of launchings per year for the next several years. It is likely, however, that increased expenditures in the advanced technical development category will be required in future years to exploit the new information resulting from the flight research results which may be expected.

Under the flight research program category, the fiscal year 1961 amounts of $3,200,000 for "sounding rockets" and $3 million for "payloads" are each within 4 percent of their fiscal year 1960 appropriations, and reflect the leveling off of the effort in this research program. The average cost per sounding rocket is $27,000, which will allow 120 rockets to be purchased with the requested funds. This number provides 1 backup rocket for every 5 launching attempts, to achieve 100 successful launchings. The cost per individual sounding rocket ranges from a low of $6,000 for the Arcon, which carries 30 pounds to 65 miles, to a high of $50,000 for the Javelin, which carries 90 pounds to 700 miles. It has long been the experience in sounding rocket programs that, on the average, payload costs are very nearly equal to rocket costs, and these two items reflect this experience.

In summary, the requested amount of $8 million to conduct the sounding rocket program during fiscal year 1961 represents a decrease of nearly 10 percent below the fiscal year 1960 appropriation. It is the minimum amount required to investigate this important region of space around the Earth which is inaccessible to any other vehicle, but through which every one of our satellites and space probes, manned and unmanned, must pass.

Meteorological Satellite Program

OBJECTIVES

The overall objective of the NASA meteorological satellite program is to establish a meteorological satellite capability for worldwide coverage and for providing observations of atmospheric elements required by the meteorologist in order to understand atmospheric processes and predict the weather. These elements include cloud cover, storm location, precipitation, temperature, wind direction, heat balance, water vapor and other constituents. To achieve this objective will require: (*a*) the development of stabilized satellites for polar orbits of 500- to 1,000-mile altitude and "stationary" satellites for equatorial orbits of 22,000-mile altitudes; (*b*) the development of suitable onboard detection equipment, including television, infrared detectors, radar, and spectroscope; and (*c*) the development of adequate data storage, handling and communications equipment, and techniques.

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The long-range objective is to develop the principles of a system of instrumented orbiting satellites and communications network by means of which worldwide meteorological information may be transmitted to the National Meteorological Center of the Weather Bureau for its operational use.

NASA METEOROLOGICAL SATELLITE FLIGHT SCHEDULE

The Tiros series of meteorological satellite launches will take place during this year—one during the first quarter and one during the third quarter. The satellites in this series will be spin stabilized and so will have a fixed orientation in space. They will be launched in an inclined orbit, thus further limiting their coverage to the area between two latitudes (50° N. and 50° S.). The basic instrumentation will be a vidicon television system by means of which cloud cover information will be viewed and transmitted back to a read-out station. In Tiros II, infrared radiation sensors will also be included.

Following the termination of the Tiros series in the summer of 1960, there will begin a 5-year program in the Nimbus series of meteorological satellites. This will be a family of satellites with many common components (data storage, controls, orientation, stabilization, data transmission, structure, etc.) and a flexible capability for improving old and introducing new sensory systems, as required. Additional details of the Nimbus satellites are discussed below.

Launchings will be twice a year in a 600-mile polar orbit using Thor Agena B vehicles. Nimbus I is planned to be launched during the third quarter of calendar year 1961 with each succeeding satellite following 6 months later.

PROGRAM OBJECTIVES IN FISCAL YEAR 1961

Early in fiscal year 1961, the second of the first generation meteorological satellites (Tiros II) will be launched. The cloud cover and radiation data from the Tiros series will be analyzed and correlated with the more standard meteorological observations. These studies will then provide the most complete description of global atmospheric events available to date. In addition, techniques of data interpretation will be developed for use in subsequent satellite experiments. Implications relative to improved weather forecasting will be pursued.

Experience with the development of the Tiros series of satellites has suggested the course of the next generation of meteorological satellites—the Nimbus series. The Nimbus series will have advanced sensor equipment for the viewing of cloud cover and the measuring of infrared radiation. In addition, Nimbus will have two features badly lacking in the Tiros series. Nimbus will always face the earth (earth stabilized) and will thus eliminate the undesirable feature of Tiros of frequently looking out into space (space stabilized). The availability of the Pacific Missile Range during 1961 for the Nimbus launch will make a polar orbit possible. Thus, Nimbus will be able to view the atmosphere over the entire globe and will provide a much greater coverage of the globe than Tiros whose view was limited essentially to the area between 50° north and 50° south latitude.

Together with the metorological analysis of the Tiros satellite data, the prime objective in fiscal year 1961 of the meteorological satellite program is to develop the necessary satellite and vehicle in preparation for a launch of Nimbus I in the summer of 1961.

Improvements in future satellites of the Nimbus series will be sought through the continuance of an aggressive program in the development of advanced instrumentation. As the improvements are perfected they will be made part of the flight program.

NIMBUS I—LAUNCH VEHICLE

The launch vehicle for the Nimbus series will be the Thor Agena B. It is a two-stage vehicle in which the first stage consists of a production Thor with the nose cone and guidance unit removed. The first-stage propellants are liquid oxygen and RP–1 (kerosene-like) fuel. The second stage consists of an Agena B vehicle. The Agena B is an improved version of what was previously designated as the Hustler stage. It is powered by a 15,000-pound thrust engine which uses storable rocket propellants—IRFNA and UDMH.

In the Nimbus I launch, the Thor Agenda B will lift a 650-pound payload to an altitude of 600 miles. The orbit will be circular and inclined approximately 80°, slightly retrograde, so that the plane of the orbit always includes the

earth-sun line. By proper choice of launch time, the satellite will always pass over chosen areas at local noon.

In fiscal year 1961 $5,700,000 are indicated for the acquisition and launch of booster vehicles. This money will partially fund two basic Thors and two basic Agena B's. However, only one launch needs to be funded during this fiscal year. The Tiros I vehicle (Thor Able) was funded by the DOD during the period of inception of the program in that agency. The Tiros II vehicle (Thor Delta) was funded under the Delta vehicle development program. Consequently, no booster vehicle costs are indicated in the meteorological satellite program in fiscal year 1959 and fiscal year 1960.

NIMBUS I—THE SATELLITE

The Nimbus satellite will be separated from the Agena stage upon injection into orbit. Its weight will be 650 pounds and its life expectancy from 3 to 6 months. It will consist of three subsystems—power, stabilization, sensory.

The power subsystem will consist of two paddle-like structures covered with solar cells and arranged to face the sun directly, whenever the satellite is in the sunlight. Nickel-cadmium storage batteries will be used for power storage. The average power input of the power subsystem will be 200 watts per orbit.

The stabilization subsystem will keep the satellite pointing directly at the earth with an accuracy of 1 degree in all three axes—roll, pitch, and yaw. The perturbation rates will not exceed 0.1° per second in any of the axes. Pneumatic jets will provide the coarse control and inertia wheels, the fine control.

The sensory subsystem will consist of (1) an improved TV vidicon subsystem to provide almost complete coverage of the globe, (2) an electrostatic tape subsystem to permit higher resolution studies of specific meteorological events, such as hurricanes, (3) a comprehensive infrared radiation subsystem containing (*a*) high resolution (5-mile) sensors for coarse nighttime cloud cover representation (*b*) medium resolution (30-mile) sensors for atmospheric and terrestrial radiation measurements and (*c*) low resolution (300-mile) sensors for gross measurements of the earth-atmosphere heat balance and (4) auxiliary measurements of importance to meteorology: measurements of the solar constant, solar ultraviolet radiation, and solar microwave radiation.

To complete the Tiros II payload program and develop the Nimbus payload will require an estimated $9,200,000 in fiscal year 1961. This, on the surface, seems to be a very large increase over the Tiros effort as indicated in the fiscal year 1959 and fiscal year 1960 figures. However, not shown is $7,977,000 provided by ARPA in fiscal year 1959 for the Tiros payload development either directly to the contractor or through NASA following the transfer of the program from the DOD to NASA.

DEVELOPMENT OF ADVANCED INSTRUMENTATION

NASA is maintaing an active instrument development program to improve the performance and reliability of existing flight instruments and for developing new instrumentation to provide additional meteorological data not yet available. Existing electronic components and systems will be improved and development will continue on infrared radiation scanning detectors and direct radiation sensors.

Among the new kinds of instrumentation, development will proceed with satellite radar for measuring precipitation, image orthicon TV systems for day and night cloud cover picture taking, and a satellite spectrometer for the fine resolution measurements of certain radiation intervals. The evaluation and testing of new horizon detectors, gyro controls, torque controls and reaction jets to afford stabilization and control for the new generation of satellites will be pursued aggressively.

For fiscal year 1961, $4,400,000 are requested for the development of advanced instrumentation. This is an increase of about one-third over the expenditures in fiscal year 1960 in this area. The major increase in activity in fiscal year 1961 over fiscal year 1960 in advanced instrumentation is essentially in the development of the proper kind of attitude stabilization which is indispensable to the satisfactory performance of the Nimbus satellite.

BASIC RESEARCH

Concurrent with the flight development program and the acquisition of meteorological information, NASA will support research in the more fundamental aspects of the overall problem of utilizing satellites for meteorological purposes. This includes—

(1) the study of satellite simulated data from other sources, e.g., rocket probes, aircraft reconnaissance, and standard meteorological observation sources;

(2) studies of basic atmospheric physics related to possible satellite instrumentation;

(3) basic radiation studies including the interpretation of balloon-flown radiation sensors;

(4) investigation of systems for simplifying the presentation of data;

(5) studies for reducing the amount of information transmitted by the satellite by providing on-board analysis.

The funding required to conduct this research program in fiscal year 1961 is $1,400,000 which is essentially at the same level of effort as in fiscal year 1960.

SUMMARY COMMENT

NASA considers its meterological satellite research and development program a serious and practical effort to produce the basis for a meteorological system that will have significant influence on the Nation's agriculture, commerce, transportation, communications, and military activities.

The funds requested have been limited by a consideration of the best use of the present manpower, technological development, and government and industrial resources in this area of national endeavor. A reduction in the requested funding level would seriously hamper the logical development of this carefully integrated program by reducing the university, industry, and Government research basis and by slowing the development of flight hardware and vehicles. This will produce a stretchout of the flight program that can only result in the delay of the applications of these initial efforts to the creation of an operational meteorological system of wide national benefit.

Lunar and Planetary Program

Perhaps no area of man's conquest of space captures the imagination so much as does the exploration of our near neighbors in the solar system. The enthusiastic reception by the world at large of the successful Soviet lunar flights emphasizes thist fact. These same people wait and watch to see if the United States has the scientific curiosity, the technical excellence, and the national vigor to match these efforts.

The NASA has established a sound program for the exploration of the Moon, Mars and Venus which is designed to provide leadership in acquiring scientific knowledge about these bodies. The program is far from an extravagant one. Rather, it is soberly conceived to exploit an orderly evolution of launching vehicles, spacecraft, and scientific payloads to the achievement of several selected goals. Within the next half decade these goals may be simply illustrated by their related missions, which are—

1960, Interplanetary probes.
1960, Lunar orbiters.
1961–62, Lunar impacts (reconnaissance).
1962, Planetary probes to Mars and Venus.
1963–64, Lunar soft landings.
1965, Planetary orbiters to Mars and Venus.
1965, Lunar soft landing with mobile vehicle.

The scientific objectives of these missions are no less exciting than the spectacular flights themselves. As our nearest major body in the solar system, unchanged by winds and rain in the several billion years of its, and the Earth's existence, the Moon offers unique opportunities for a better understanding of the solar system. On Mars and Venus we can look forward to the possibility of some form of life, the discovery of which could prove far more than a scientific curiosity. What scientific finds actually await us we can only speculate. If we knew the answer to this question the program would lose its meaning.

Just as the planned missions constitute an orderly sequence of technological and scientific development, so do they lay the groundwork for the more difficult missions to follow. The program is now in its formative stages. The fiscal year 1961 budget request is minimal in that it provides for a minimum of backup flights and contains no funds for contingencies. Failure to support it at this point must be recognized as jeopardizing the entire national posture in this most important area.

The actual programed flight schedule, which presumes acceptance of the fiscal year 1961 budget and which must be considered tentative beyond 1962, is shown below:

Mission	1960	1961	1962	1963	1964	1965
Lunar orbiter	A A	Test				
Lunar impact		Ag Ag Ag	Ag Ag			
Lunar landing				C C C	C C C	C S
Interplanetary probe	T T					
Planetary probe			C C		C	
Planetary orbiter						S S

Key: T=Thor Able or Delta, A=Atlas Able, Ag=Atlas Agena B, C=Centaur, and S=Saturn.

This mission schedule has been developed in accord with the following principles.

1. Select the most important goals and pursue them with determination.
2. Establish an evolutionary sequence of missions where each step paves the way for the more difficult phase to follow and which makes full use of increased technological capability as it becomes available.

LUNAR MISSIONS

Consider first the lunar missions. These missions are clearly oriented toward the achievement of controlled lunar landings. It is the feeling of the NASA that this approach will yield the maximum scientific results and will pave the way for more ambitious manned lunar missions at some later date. The series begins with two attempts to place an instrumented payload in orbit about the Moon using the Atlas-Able booster. These missions represent our best current capability and are, in fact, the third and fourth attempts at this mission following two failures in 1959.

These missions utilize a spin stabilized payload with rudimentary but effective midcourse guidance, without which the mission could not be accomplished at this time. The payload contains a variety of radiation detection experiments to make measurements in the lunar environment. As an "anchored" space station away from the Earth's influence, the payload assumes additional importance when its long-term measurements are compared with related measurements in the vicinity of the Earth.

In 1961 the NASA will begin the second phase of the lunar program. The Atlas-Agena B will be used to launch a new spacecraft to achieve a controlled lunar impact with survivable equipment.

It now becomes necessary to understand what is meant by the term "spacecraft." A spacecraft is a vehicle designed to fly through space carrying a useful payload and maneuvering as required to maintain the desired course and orientation. In earlier days the scientific payload and telementry equipment were packaged into a structure which was little more than a can and which either tumbled freely or was spin stabilized. In contrast, the soft landing lunar spaceship of the future may be likened to a fighter aircraft in complexity and cost. This is readily understandable when one considers that this remote descent to the lunar surface is without benefit of an atmosphere and that the total deceleration and landing is dependent on rocket braking and appropriate electronic sensing equipment to guide and control this braking.

Returning to the sequence of Agena B launchings, the firsttwo in April and July of 1961 will actually not be directed toward the Moon but rather into orbit about the Sun to test vital spacecraft components and at the same time conduct selected scientific experiments. By October or November of 1961 the first of three attempts at the complete lunar mission will be ready. The spacecraft for this

mission is being developed by the Jet Propulsion Laboratory and will consist of two sections. The main section will contain guidance and control, telemetry, and propulsion equipment which will make it possible to impact the Moon within a predetermined area and with attitude control during the entire flight. In addition to carrying scientific instruments for measurements in cislunar space, this section of the payload will carry a television camera capable of transmitting during the final moments of flight pictures of the impact area having optical resolutions of less than 10 feet. The spacecraft is also being designed to carry a capsule which will be slowed by a retro-rocket from about 8,000 feet per second so that its impact velocity will be less than 500 feet per second. Survivable equipment within the capsule may include instrumentation to study the lunar surface consistency, structure, and temperature.

In 1963 the availability of the powerful Centaur should make possible the first true lunar soft landing of a spacecraft carrying television, a seismograph, a spectrometer, and radiation detection devices among other relatively fragile scientific instruments to observe and analyze the lunar surface and subsurface properties. Telemetry and an electric power supply must also be included in the same 600 pounds of structure and equipment which can be deposited relatively gently on the lunar landscape. The television reconnaissance of the terrain obtained in the preceding Agena series should facilitate the design of the Centaur spacecraft landing structure, for example, must we contend with boulders and crevasses. A long life span is predicted for this spacecraft since we will want to conduct spot investigations of relatively many lunar areas over a period of years.

The Saturn soft landing spacecraft will be required for those areas of the Moon which we want to explore intensively, either for purely scientific reasons or to lay the groundwork for manned landings. This spacecraft will weigh at least several times that of the Centaur. This vehicle, planned for 1965 with a 3-to 4-year leadtime for development, is planned to be self-powered for mobility over the lunar surface. By this technique the actual area which may be explored and sampled will increase manyfold. Here again, television will play a key role in this remote exploration.

PLANETARY AND INTERPLANETARY MISSIONS

Turning now to the planetary and interplanetary missions, a Thor Able and a Thor Delta will be launched this year to obtain scientific measurements of magentic fields and of particle and electromagnetic radiation fields deep into interplanetary space. Our first capability of launching probes into the vicinity of Mars and Venus will come in 1962 when it is planned to use the Centaur launch vehicle and a variation of the JPL spacecraft designed for use on the Atlas-Agena lunar missions. These planetary probes are designed to pass close enough to the planets to permit critical scientific measurements to be made and transmitted back to Earth. Television and/or spectrographic observations are among the most exciting possibilities, although difficult to achieve due to guidance problems and uncertainties in the position of the planets.

In 1964 another favorable opportunity to fire at Venus will occur. This flight will probably be used to test stellar navigation equipment planned for operational use aboard the Mars and Venus orbiting spacecraft scheduled for launch with the Saturn in 1965. These latter spacecraft will weigh several thousand pounds and are conceived as ejecting instrumented capsules to penetrate the atmosphere of the two planets. The possible returns from such sophisticated techniques are fascinating to contemplate.

BUDGET CONSIDERATIONS

It is not necessary to project beyond 1965 in consideration of the fiscal year 1961 budget. Lead times are such that only relatively small amounts of the requested funds will be applied to the most distant missions discussed. The $45 million requested by the NASA for lunar and planetary exploration is planned for obligation as follows.

Advanced technical development, $9,000,000

These funds will be partially expended for research and development of scientific experiments for potential use on the advanced flight missions described above. The balance will be used to acquire instruments for the five Atlas-Agena lunar missions and the first two Centaur planetary missions. The approximate breakdown is as follows:

1. Scientific research and development (some 20 separate projects), $2,000,000.
2. Development and procurement of flight experiments, $7,000,000.

Flight research program, $36,000,000

These funds will be used for the following areas:

(*a*) Incremental payment on Atlas-Agena vehicle.

(*b*) Completion of lunar orbiter projects.

(*c*) Develop and construct spacecraft for the lunar impact and planetary probe missions including spares for test purposes. Some funds from fiscal year 1962 will be required to complete this work.

(*d*) Develop, procure, and operate special ground equipment in support of these spacecraft.

(*e*) Research and development on spacecraft technology applicable to advanced missions scheduled beyond 1962. (In this regard, approximately $17 million of the navigation, guidance, and control funds listed under vehicle systems technology will be applied in fiscal year 1961 to systems development for the lunar soft landing vehicle for the Centaur and, to a lesser extent, the Saturn.)

The approximate breakdown by technological category is as follows:

Atlas-Agena incremental payment	$9,500,000
Completion of lunar orbiter projects	3,500,000
Trajectory calculations and mission studies	1,500,000
Technical documentation	600,000
Communications equipment	5,200,000
Ground support equipment	1,500,000
Guidance and control equipment	3,000,000
Payload integration and environmental test	4,000,000
Solar power supplies	1,500,000
Flight structures	1,700,000
Survivable capsule development and procurement	2,500,000
Saturn spacecraft studies	1,500,000

Explanation for Major Repairs and Alterations

(Fiscal Year 1961 Estimates)

The following paragraphs contain descriptive material on some of the "Major repairs and alterations" items for the Langley, Ames, and Lewis research centers.

LANGLEY RESEARCH CENTER

Modifications to equipment to develop instrumentation for interplanetary orbiting vehicles, $75,000

These modifications are required to conduct research on requirements, techniques, and components needed to stabilize and orient satellites or other space vehicles and their components, such as antennas and solar collectors. Two vertical rocket firings are planned using infrared techniques.

Improvements to radar equipment for detecting objects during atmospheric reentry, $100,000

These modifications are required to provide research tools for studies of detection, discrimination and accurate tracking of both satellites and reentry vehicles. This research is of a general nature but may have direct application to the ballistic missile defense problem.

Installation of equipment for developing airborne detectors for guidance of interceptor missiles, $100,000

Instrumentation must be developed having greater accuracy, economy of power, and less weight for such missions as rendezvous of spacecraft and putting satellites into lunar and other planetary orbits. The equipment will be used also to study various guidance and navigation techniques.

Modifications to equipment to provide measuring devices for reentry heating and thermal radiation, $152,000

These modifications will permit the study of the transmission, reflectivity, and absorption of various materials, coatings and structures over a wide spectrum of radiation wavelengths from ultraviolet to infrared. Such measurements are

required in determining the behavior in a radiation environment of radiators, solar collectors, and the structure of the vehicle.

Installation of equipment for heat transfer ablation studies, $120,000

This equipment will allow studies of heat transfer and ablation cooling combined with gas ejection cooling over space vehicle bodies. The study of such techniques is necessary to provide heat protection systems for reentry vehicles such as Dynasoar.

AMES RESEARCH CENTER

Installation of a high-pressure air and helium distribution system, $128,000

This system will connect six wind tunnels to an existing 3,000 per square inch air and helium supply so that only one unit of equipment and personnel can provide the required service. In addition, the helium will be reprocessed and reused where previously it was wasted to the atmosphere.

Modification of hypervelocity ballistic range to increase test capabilities, $175,000

This modification will provide increased altitude simulation by a factor of 10—(to .0001 atmospheres)—and a flash X-ray system to study the basic physics of meteorite impact. Initially, the facility was used to study aerodynamic heating, however, its size and speed are well suited to other problems of immediate concern.

Alterations to airplane hangar No. 2 to provide heating facilities, $85,000

The hangar was built in 1944 without heating facilities according to War Production Board specifications. Maintenance was provided by moving the airplanes to a heated hangar; however, the heated hangar has been converted to other research uses such as for simulation and centrifuge equipment. Heated space must be provided for maintenance and checkout of the aircraft and the on-board electronic equipment.

LEWIS RESEARCH CENTER

Installation of combustion tunnel for studies on solid propellants, $70,000

Little is known about the effects of steady-state and oscillatory aerodynamic forces on the combustion behavior of solid propellants such as used in Minuteman and Polaris. This equipment will permit ground studies of the effect of controlled oscillations and steady-state forces on the combustion process, thereby leading to engineering solutions to burn-out and reliability problems.

Alterations to 10-foot supersonic tunnel for research on problems of takeoff and landing of rocket-powered vehicles, $35,000

The landing and take-off of rocket-powered vehicles from the Moon or the planets Mars and Venus will cause problems due to the ground reflection and engulfing of the vehicle by the exhaust gases. A low-pressure environment is needed to study jet reflection and recirculation effects. The 10-foot tunnel can be easily modified to provide this environment.

Installation of equipment for liquid propellants pressurization research, $40,000

Rocket engine reliability may be improved by substituting a pressure fed system for a complex turbopump to drive the propellants. Equipment to produce the gas pressure and to determine its effects on the propellant system weight and performance is needed.

Modification to test rig for research on gas generator and heat exchanger systems for space vehicles, $80,000

Present equipment for these critical studies does not have sufficient flow capacity. Modifications to increase the flow capacity to more realistic rates and to handle propellants other than liquid oxygen and liquid hydrogen are planned.

Modification of equipment for research on liquid oxygen-liquid hydrogen flow systems, $60,000

Equipment is planned for ground studies of complete flow system including tanks, controls, and nozzles. One of the objectives of these studies is to obtain correlations for the scaling up of data from small rocket systems to be applicable to large rocket systems.

Installation of test facility for studies on scale effects of liquid hydrogen fuel tanks, $70,000

Current tank material research studies employ 6-inch diameter tanks. Tensile test correlation for 30-inch diameter tanks are needed to insure the research results are applicable to full-scale missiles.

Explanation for New Equipment Needs

(Fiscal Year 1961 Estimates)

LANGLEY RESEARCH CENTER

The Langley Center is conducting a large program on the reentry of orbiting and space vehicles with particular emphasis on structural resistance to flutter and high temperature, means for vehicle detection and tracking, and vehicle stabilization and control. Some of this work can be done in ground facilities and some must be conducted with small-scale, rocket-powered models. In regard to the latter, the present telemetering load will be taken over by long range radar equipment within the next 5 years. Another requirement is for metal fabrication equipment to make models from the high temperature alloys needed to withstand the high structural temperatures encountered in reentry.

A table giving several examples of scientific and research equipment and machine tools and its cost is listed below:

Radiant heater and controls for unitary plan tunnel for flutter studies at reentry temperatures	$44,500
Equipment and instrumentation for research on space vehicle design and construction using rocket-launched models	200,000
Machine tools for stretch forming of superalloys into complex shapes without damaging the metal	100,000

AMES RESEARCH CENTER

This center is particularly concerned with fundamental studies of reentry into the Earth's atmosphere at high velocities (36,000 feet per second) and the stabilization and control of space vehicles. All of the new equipment is for the newer fields of research relating directly to these two fields. Equipment for determining the fundamental properties of air, the erosion characteristics of materials, and an airborne digital computer are needed.

The following table lists several examples of scientific and research equipment and its cost:

Equipment for measuring the physical properties at very high temperatures of gases and gaseous mixtures which may be found in planetary atmospheres	$180,000
Microminiature telemetering equipment to improve the accuracy of heat transfer and pressure data obtained from ballistic ranges and the supersonic free-flight tunnel (telemeter circuitry is now available which can be placed into models measuring only 0.5 by 0.25 inch)	90,000
Airborne digital computer equipment for investigations of control and guidance systems for spacecraft	80,000
Installation of equipment to simulate the interactions of protons in space with the Earth's atmosphere (studies with this equipment should be of assistance in interpreting the results obtained from satellite and space probe experiments)	60,000

LEWIS RESEARCH CENTER

This center is conducting the major portion of NASA advanced research on space propulsion and electrical power generation methods. Equipment is needed to simulate the effects of fluids on the space environment under conditions of zero gravity, high radiation, and very low temperatures. Models are required for small-scale studies of stage separation, the recovery of large and costly boosters, so they may be reused, Moon landing propulsion systems, and vehicle attitude control problems. Experimental electrical rocket components such as ion sources, accelerator grids, and AC and DC power supplies are needed to

continue the research program started several years ago. Scientific equipment is needed for nuclear systems research for use at the Plumbrook Reactor Facility. Equipment for controlled atmosphere welding of high temperature alloys such as tungsten, tantalum, and molybdenum is desired.

The following table lists several examples of scientific and research equipment and its cost:

Small-scale models and model positioning equipment for studies of booster stage separation	$175,000
Equipment for laboratory tests of a small but complete hydrogen-fluorine rocket engine system capable of restarts without refueling (such systems are required for very long duration space missions)	240,000
Equipment for research on liquid fueled rocket engines consisting of thrust chambers and their major parts—injector, combustion chamber, and nozzle	225,000
Installation of a gimbaled mount in the attitude wind tunnel for tests of control systems of large boosters (no major modifications to the wind tunnel are required)	200,000
Installation of equipment studying storable liquid propellant and rocket engine systems in zero gravity conditions (an AJ–2 airplane has been provided by the Navy for the zero gravity flights)	210,000
Components for ion and plasma rocket engines	150,000
Measurement and analysis equipment for use with ion and plasma rocket engine research (test times for this research are extremely short, but each test requires a long setup time; consequently, it is desirable to obtain the maximum amount of data from each test)	35,000

FLIGHT RESEARCH CENTER

This center is primarily concerned with the research that must be conducted with flight vehicles. Of particular importance is the need for high speed, airborne recording equipment and the supporting ground equipment for analyzing the data.

The following table lists several examples of scientific and research equipment and its cost:

Installation of analog computer equipment for studies of control problems of boost-glide and other reentry spacecraft	$65,000
Equipment for very accurate presentation of flight condition data to the pilots of high performance aircraft used for research purposes	18,000

EXPLANATION FOR RECURRING EQUIPMENT NEEDS

(Fiscal year 1961 estimates)

LANGLEY RESEARCH CENTER

This center is heavily engaged in research and development work using rocket-propelled models which experience speeds in excess of 20,000 feet per second and temperatures to above 15,000° F. The indicating and recording equipment must have greater speed and ranges of sensitivity and accuracy than that which is suitable for aircraft-type research. In order to obtain the maximum amount of data from a single rocket firing, more capacity and greater ranges for telemetering units must be obtained, necessitating procurement of even more miniaturized and powerful units. A large increase in electrical and electronic equipment is necessary for the large and complicated research payloads which are planned for use with the Scout rocket. The equipment will be used in studies of inflation of flexible reentry vehicles, attitude orientation, determination of temperature and tracking of spacecraft, and determination of the best methods of returning people and cargo to the Earth from orbiting or planetary missions. Operating and testing equipment primarily involves equipment for testing the performance and reliability of contractor-furnished equipment to be used in the world-wide tracking network for which this center has prime responsibility.

The following table gives some examples of this equipment and its cost:

Indicating and recording equipment:	
Electrical and electronic:	
Force, torque, and vibration instruments	$12,000
Oscillographs and related amplifiers	50,000
Pitot and flow direction sensors	110,000
Potentiometers and other meters	120,000
Temperature measuring equipment	25,000
Mechanical and hydraulic:	
Pressure pickups and transmitters	175,000
Position and angle measuring equipment	20,000
Accelerometers	45,000
Photographic and optical:	
Cameras	12,500
X-ray machine and associated equipment	20,000
Schlieren optical equipment	8,500
Operating and testing equipment:	
Electrical and electronic:	
Amplifiers	28,000
Gyroscopes	12,000
Radar beacon test equipment	32,000
Signal generators	9,000
Mechanical and hydraulic: Hydraulic jacks	1,000
Photographic and optical: Interference filters (spectography)	3,500

AMES RESEARCH CENTER

This center operates several unique ground facilities which can produce speeds up to 36,000 feet per second for studies of the basic phenomena of ionization, heat transfer, meteorite damage, and reentry physics in general. Photographic equipment with very high speeds is required—movie cameras with speeds of between 1½ million to 2 million frames per second. Pressure transducers which have very large ranges of sensitivity and which can operate over a large temperature range are required for this type research.

The following table gives some examples of this equipment and its cost:

Indicating and recording equipment:	
Electrical and electronic:	
Transducers	$24,000
Potentiometers	22,000
Indicating meters and recorders	20,000
Oscilloscopes	21,000
Mechanical and hydraulic:	
Gauges, testers and analyzers	7,500
Gyroscopes	6,500
Accelerometers	4,500
Photographic and optical:	
Cameras	11,500
Projectors	1,500
Photoconductive cells	1,500
Operating and testing equipment:	
Electrical and electronic:	
Amplifiers	19,000
Inverters	4,500
Generators	4,500
Capicators	1,000
Mechanical and hydraulic:	
Pumps	14,000
Balance and weights	2,000
Valves	1,200
Pressure regulators	1,000
Photographic and optical:	
Lenses	3,400
Microscope equipment	3,200
Infrared source	1,000

LEWIS RESEARCH CENTER

This center is engaged in rocket propulsion research wherein very high exhaust temperatures and very low propellant and tank temperatures are experienced. It is engaged also in ion and plasma propulsion research wherein large amounts of electrical power occupying a very small space is required. In addition, this center will be operating a nuclear reactor wherein components of space propulsion systems will be investigated. Temperature, pressure, radiation and electric current sensing instruments which must operate with better accuracies than those now in use at 350° below zero in the presence of nuclear radiation are required. In addition, pumps and valves are required which must handle liquid hydrogen, nitrogen, and liquid metals, and the highly reactive fuels and oxidizers used in liquid fueled rockets.

The following table gives some examples of this equipment and its cost:

Indicating and recording equipment:	
Electrical and electronic:	
Temperature measuring and control instruments	$5,200
Current and voltage measuring instruments	3,800
Flowmeters and transmitters	14,000
Radiation detection instruments	6,000
Noise measuring instruments	3,200
Mechanical and hydraulic:	
Pressure pickups and transmitters	33,000
Pressure gauges and regulators	11,700
Photographic and optical:	
Optical pyrometers	2,500
Microscopes	2,500
Operating and testing equipment:	
Electrical and electronic:	
Starters and switches	5,800
Transformers	5,500
Capacitors	2,100
Motors and generators	2,500
Mechanical and hydraulic:	
Pumps	40,800
Valves	48,000
Gauges	7,000
Powder metallurgy equipment	2,600
Photographic and optical:	
Cameras and accessories	8,700
Lights	2,500

FLIGHT RESEARCH CENTER

This center will be heavily involved in the X–15 research airplane program in addition to other programs involving the operation of high performance airplanes. Fast recording, lightweight airborne instruments for pressure, temperature, and pilot's physical condition will be required. In addition, electronic simulator equipment will be required for preparing the pilots for the unusual flight conditions they will encounter at speeds of 4,000 miles per hour and altitudes up to 250,000 feet.

The following table gives some examples of this equipment and its cost:

Indicating and recording equipment:	
Electrical and electronic:	
Transducers	$15,000
Temperature gauges	15,000
Mechanical and hydraulic:	
Gyroscopes	3,000
Hydraulic valves and plumbing	3,000
Photographic and optical: Cameras	6,000
Operating and testing equipment:	
Electrical and electronic:	
Transformers	5,000
TV components for ground simulator	4,000
Photographic and optical: Cameras	6,000

RESEARCH GRANTS AND CONTRACTS OF NASA

[As of Nov. 1, 1959 (last report dated Aug. 1, 1959)]

PHYSICAL SCIENCES

PHYSICS

Control number	Agency	Participant	Date	Duration	Amount
NAw-6553	California Institute of Technology Investigation of wave motion in conducting fluids including the construction of facilities for work on and preliminary studies of magnetohydrodynamic processes.	Liepmann	Sept. 9, 1958	12 months	$37,895
NASw-13	University of Virginia Experimental investigation of ionization phenomena by high-velocity molecular beams including the design, construction, and preliminary testing of the apparatus having highest possible beam intensity with minimum beam energy and minimum spread in beam energy.	Lowry and Miller	Dec. 11, 1958	do	34,200
NsG-12-59	New York University Theoretical investigation of molecular states, including computation of hybrid and exchange integrals, calculation of matrix elements, and preliminary calculations of potential curves for upper atmosphere constituents (continuation NAw-6541).	R. C. Sahni	March 1959	do	49,525

Reports Received to Date on This Investigation

Sahni, Roop C., and Cooley, James W.: Derivation and Tabulation of Molecular Integrals.

Sahni, Roop C., and Cooley, James W.: Derivation and Tabulation of Molecular Integrals. Supp. I—Tables for Two-Center One-Electron Nuclear Attraction, Overlap, and Potential- and Kinetic-Energy Integrals.

Sahni, Roop C., and Cooley, James W.: Derivation and Tabulation of Molecular Integrals. Supp. II—Tables for Two-Center Two Electron Coulomb Integrals.

Sahni, Roop C., and LaBudde, C. D.: A Study of Molecular Integrals. I—Two-Center Exchange.

LaBudde, C. D., and Sahni, Roop C.: A Study of Molecular Integrals. II—Three-Center One-Electron Integrals.

Control number	Agency	Participant	Date	Duration	Amount
NsG-1-59	Yale University Investigation of molecular beam frequency standards and atomic collison cross-sections.	V. W. Hughes	Apr. 1, 1959	12 months	$110,000
NsG-5-59	University of Maryland Investigation of the forces between atoms, molecules and ions at small separation distances for use in the evaluation of properties of gases at very high temperatures (continuation NAw-6537).	Mason and Vanderslice	April 1959	3 years	59,426

RESEARCH GRANTS AND CONTRACTS OF NASA—Continued

PHYSICAL SCIENCES—Continued

Reports Received to Date on This Investigation

Vanderslice, Joseph T., Mason, Edward A., and Maisch, William G.: Interaction Between Oxygen and Nitrogen: O–N, O–N_2, and O_2.

Mason, Edward A., Vanderslice, Joseph T., and Yos, Jerrold M.: Transport Properties of High-Temperature Multicomponent Gas Mixtures.

Vanderslice, Joseph T., Mason, Edward A., and Maisch, William G.: Interaction Between Ground-State Oxygen Atoms and Molecules: O–O and O_2–O_2.

Fallon, Robert J., Vanderslice, Joseph T., and Mason, Edward A.: Quenching of Excited Hg($3p_1$) by NO.

Vanderslice, Joseph T., and Mason, Edward A.: Relations Among Potential Energy Curves of Diatomic Molecules.

Fallon, Robert J., Mason, Edward A., and Vanderslice, Joseph T.: Energies of Various Interactions Between Hydrogen and Helium Atoms and Ions.

Fallon, Robert J., Vanderslice, Joseph T., and Mason, Edward A.: Mechanism of Ozone Production by the Mercury Sensitized Reaction of Oxygen.

Vanderslice, Joseph T.: Determination of Short-Range Intermolecular Forces.

Vanderslice, Joseph T., and Mason, Edward A.: Quantum-Mechanical Calculations of Short-Range Intermolecular Forces.

Mason, Edward A.: Methods for the Calculation of High-Temperature Gas Transport Properties.

Control number	Agency	Participant	Date	Duration	Amount
NsG–11–59	California Institute of Technology Study of the fundamental parameters of fatigue failure including considerations of the effect of fatigue stressing on precipitation and of the relationship between temperature and frequency effects (continuation NAw–6496).	Valluri and Sechler	April 1959	12 months	$17,965

Reports Received to Date on This Investigation

Valluri, S. R.: A Dislocation Theory Viewpoint of the Effect of Frequency, Temperature, and Grain Size on Fatigue of Metals.

Control number	Agency	Participant	Date	Duration	Amount
NsG–6–59	Rice Institute Research on the physics of solid materials, including study of the basic laws governing the behavior of solids at high temperatures.	Franz Brotzen	May 1959	36 months	$500,000
NsG–22–59	University of Michigan Theoretical investigation of discontinuities in 3-dimensional magnetohydrodynamics.	Rudi S. B. Ong	do	do	13,000

[Grants=NsG; contracts=NAw or NASw; those lacking prefix are recommended for award, but not yet awarded]

Control number	Agency	Participant	Date	Duration	Amount
NsG–40–60	California Institute of Technology Investigations of rarified gas flows (continuation of NAw–6553) (technical representative, E. O. Pearson).	H. W. Liepmann	August 1959	36 months	$120,050
	RECOMMENDED FOR AWARD SINCE LAST REPORTED				
NsG–48–60	Rensselaer Polytechnic Institute Investigation of microwave gaseous electronics.	E. Edward Holt	November 1959	12 months, (fiscal year 1960).	36,500 9,460
NsG–50–60	University of Denver The study of atomic and molecular phenomena by high velocity atomic and molecular beams.	N. Utterback and G. H. Miller	October 1959	36 months	119,271

RESEARCH GRANTS AND CONTRACTS OF NASA—Continued

PHYSICAL SCIENCES—Continued

CHEMISTRY

Control number	Agency	Participant	Date	Duration	Amount
NAw-6552	Johns Hopkins University Experimental investigation of heterogeneous reactions in boundary layer flows, including the construction and calibration of an annular porous palladium wall reactor apparatus.	Weger	Sept. 9, 1958	12 months	$13,252
NAw-6558	Stanford University Investigation of the production by controlled progressive growth from the melt of metallurgical structures containing uniformly dispersed stable particles.	Huggins	Sept. 16, 1958	do	31,474
NASw-10	University of California Investigation of the ductile characteristics of some model ceramic systems over temperature ranges where plastic deformation is possible (continuation of NAw-6530).	Pask	Nov. 28, 1958	13 months	16,000
NsG-9-59	New York University Investigation of the feasibility of the production of breathing oxygen from space minerals.	E. R. Kaiser	April 1959	12 months	14,405
NASw-71	Batelle Memorial Institute Investigation of radiation effects of a reactor fuel-material for nuclear rockets (technical representative, David Novik).	H. H. Goldthwaite	June 1959	7 months	24,500
NASw-76	Armour Research Foundation Experimental investigation of the physical and chemical properties of a range of mixtures of fluorine and oxone to determine the feasibility of using ozone-fluorine mixtures for rocket engine oxidants.	L. C. Kinney	August 1959	12 months	55,000
NASw-111	Stanford Research Institute An investigation of the use of a reactive metal anode such as lithium and sodium to achieve a high-energy battery.	J. E. Chilton	September 1959	14 months	45,041
NASw-77	Armour Research Foundation Investigation of surface recombination rates and kinetics of atomic oxygen on specific catalytic surfaces using paramagnetic resonance techniques.	Marshall and Hacker	August 1959	12 months	34,908
NsG-42-60	Johns Hopkins University Investigation of the kinetics and mass transfer steps associated with a heterogeneous reaction occuring on the surface of a porous material under boundary layer flow (continuation of NAw-6552).	Eric Weger	September 1959	do	28,562

Reports received to date on this investigation

Weger, Eric; Bastian, W. C.; and Effron, E.: "Investigation of Heterogeneous Reactions in Boundary Layer Flows on Porous Surfaces."

Control number	Agency	Participant	Date	Duration	Amount
	RECOMMENDED FOR AWARD SINCE LAST REPORT				
	Stanford University Investigation of a technique for the production of metallurgical structures containing uniformly dispersed stable particles.	Huggins and Stevenson		12 months	$31,000

COSMOLOGICAL SCIENCES

PLANETARY SCIENCES

Control number	Agency	Participant	Date	Duration	Amount
NsG–4–59	University of Michigan Theoretical investigation of the use of radar to map planetary surfaces and to determine conductivity, permittivity, and permeability of planetary surface materials.	Siegel	April 1959	3 years	$126,000

ASTROPHYSICS

Control number	Agency	Participant	Date	Duration	Amount
NsG–15–59	University of Colorado Hs–191 National Bureau of Standards supporting services for NsG–15–59, Research on Zodiacal Light.	G. Newkirk, Jr	May 1959	24 months	$36,225 5,195
NsG–21–59	Boston University Investigation of the nature and origin of tektites (technical representative, Dr. Nancy Roman).	Gerald S. Hawkins	June 1959	12 months	9,667

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RESEARCH GRANTS AND CONTRACTS OF NASA—Continued

COSMOLOGICAL SCIENCES—Continued

[Grants=NsG; contracts=NAw or NASw; those lacking prefix are recommended for award, but not yet awarded]

ASTRONOMY

Control number	Agency	Participant	Date	Duration	Amount
HS-149	Yale University Summer institute in dynamical astronomy.	Dirk Brouwer	April 1959	1 month	$22,050
NsG-8-59	Yale University Investigation to determine the solar parallax utilizing absorption line techniques.	Lilley and Brouwer	May 7, 1959	24 months	113,660
NsG-29-60	Yale University Research on problems of satellite and planetary motion.	Dirk Brouwer	August 1959	36 months	149,580
	RECOMMENDED FOR AWARD SINCE LAST REPORT				
NsG-43-60	University of Cincinnati Fundamental research in celestial mechanics.	P. Herget	October 1959	do	178,000

LIFE SCIENCES

Programs temporarily deferred.

ENERGETICS

Control number	Agency	Participant	Date	Duration	Amount
NAw-6551	Ohio State University Investigation of parameters affecting the initiation of detonation in gaseous mixtures including determination of the effects of internal geometry in a tube upon the detonation induction distance for several combustible mixtures at initial pressures of 1 to 25 atm.	Edse	Aug. 29, 1958	12 months	$28,889
NsG-10-59	University of California Investigation of wave development during detonation of a gaseous mixture and determination of the composition profile of the wave to obtain data necessary to provide accelerating wave.	A. K. Oppenheim	April 1959	3 years	118,800
NsG-44-60	Ohio State University Investigation of parameters affecting the initiation of detonation in gaseous mixtures (continuation of NAw-6551).	Edse and Bollinger	September 1959	24 months	105,625

ELECTROMAGNETICS

Control number	Agency	Participant	Date	Duration	Amount
NsG-2-59	University of Michigan Rsch on information and communication theory pertinent to the very low signal-to-noise ratios that are encountered in space communication and telemetry.	Nichols	April 1959	3 years	$30,000

RESEARCH GRANTS AND CONTRACTS OF NASA—Continued

ENGINEERING SCIENCES—Continued

FLUID MECHANICS

Control number	Agency	Participant	Date	Duration	Amount
NAw-6549	Polytechnic Institute of Brooklyn Analytical investigation of convective heat transfer through 3-dimensional nonsteady boundary layers with and without fluid injection.	Torda	Aug. 28, 1958	12 months	$15,100
NAw-6550	University of Michigan Investigation of covitation-erosion phenomena with liquid metals including construction and initial calibration of a continuous flow fluid tunnel and associated equipment.	Hammitt	Aug. 29, 1958	do	24,370
S59-53	National Bureau of Standards Investigations of the mechanics of transition from laminar to turbulent flow in boundary layers of subsonic and supersonic flows (continuation of S58-53).		August 1958	do	50,000
NAw-6554	Stanford University Investigation of convection heat transfer in annular passages with and without asymmetric heating and eccentricity, including construction and initial testing of the sectionally heated flat duct and the variable diameter-ratio annulus apparatus.	Kays and Reynolds	Sept. 11, 1958	do	32,160
NASw-3	University of Minnesota Analytical and theoretical investigation of Prandtl number and thermal conductivity of air at high temperatures, including the measurement of recovery factor to approximately 2,000° F. and evaluation of methods for determining thermal conductivity of air at higher temperatures (continuation NAw-6527).	Eckert	Oct. 21, 1958	do	30,514

Reports Received to Date on This Investigation

Reports Received to Date on This Investigation

Eckert, E. R. G., Ibele, W. E., and Irvine, T. F., Jr.: Prandtl Number, Thermal Conductivity and Viscosity of Air-Helium Mixtures.

Control number	Agency	Participant	Date	Duration	Amount
NsG–3–59	Rice Institute Investigation of the performance and flow condition in the test section of maximum mach number wind-tunnels, including studies of temperature distribution, degree of ionization in the free-stream, boundary layer effects and nozzle shape.	A. J. Chapman, H. Beckmann	Mar. 1, 1959	3 years	$105,550

[Grants=NsG; contracts=NAw or NASw; those lacking prefix are recommended for award, but not yet awarded]

Control number	Agency	Participant	Date	Duration	Amount
HS–82	Franklin Institute Research on gas-lubricated bearings (NR 097–343b).		Mar. 17, 1959	6 months	$15,000
HS–118	Northwestern University Symposium on Magnetohydrodynamics.	A. B. Cambel	April 1959		1,676
NsG–13–59	University of Illinois Investigation of the flow and heat transfer conditions within separated flow regions.	H. H. Korst	do	12 months	23,057
NsG–20–59	University of Michigan An experimental and theoretical study of the flow about right circular cones at angles of attack up to 90° and at Mach numbers above 3.	Hans P. Liepman	May 1959	do	31,000
NsG–31–60	Massachusetts Institute of Technology Experimental investigation of the effect of sound impingement upon shear flows (technical representative, George Bates).	Erick Mollo-Christensen	August 1959	24 months	74,350
NTF–64	National Bureau of Standards Investigation of boundary layer transition (continuation of S59–53).	G. B. Schubauer	July 1959	12 months	70,000
NsG–39–60	University of Michigan Investigation of cavitation-erosion phenomena (continuation of Naw–6550).	F. G. Hammitt	September 1959	24 months	93,710
NsG–41–60	National Academy of Sciences—National Research Council Joint support of International Union of Theoretical and Applied Mechanics symposium on magneto-fluid dynamics (technical representative, Dr. Robert (Jastrow).		do	16 months	10,000
NsG–46–60	University of California Second international symposium on rarefied gas dynamics in 1960.	F. S. Sherman	Nov. 1, 1959	4 days	6,500

RESEARCH GRANTS AND CONTRACTS OF NASA—Continued

ENGINEERING SCIENCES—Continued

MATERIALS TECHNOLOGY

Control number	Agency	Participant	Date	Duration	Amount
NASw-2	Catholic University of America Experimental investigation of the flow and fracture of high-strength materials including a study of fracture strength for various strain rates and testing temperatures and the relation of fracture strength to strength levels, metal structure and carbon content of the material.	Klier	October 1958	12 months	$27,500
NASw-5	University of Michigan Investigation of the effects of trace elements on structure, high temperature strength, and fabricability of high temperature and refractory alloys (continuation on NAw-6534).	Freeman	Nov. 12, 1958	do	50,000

Reports Received to Date on This Investigation

Decker, R. F., Rowe, John P., and Freeman, J. W.: Boron and Zirconium From Crucible Refractories in a Complex Heat-Resistant Alloy. NACA Rep. 1392, 1958.

Decker, R. F., Rowe, John P., and Freeman, J. W.: Vacuum-Induction, Vacuum-Arc, and Air-Induction Melting of a Complex Heat-Resistant Alloy. NASA TN D-6, 1959.

Control number	Agency	Participant	Date	Duration	Amount
HS-34	National Bureau of Standards Investigation of the effect of surface reaction on fatigue failure. HS-34 projected completed. Proposal No. 502 approved for continuation.		Nov. 15, 1958	7½ months	$18,417
NASw-8	Denver University Investigation of the scavenging action of selected rate earth metals with tungsten and molybdenum alloys, including an investigation of the effects of the rare earth metals on dispersion strengthening of the tungsten and molybdenum alloys at high tempratures.	Nachman	Nov. 20, 1958	12 months	49,815
HS-35	National Bureau of Standards Investigation of cross-linking of transparent polymers by radiant energy (continuation S57-55).	G. M. Kline	Dec. 1, 1958	7 months	17,500

Reports Received to Date on This Investigation

Parker, Midgett S., Krasnansky, Victor J., and Achhammer, Bernard G.: Effects of Composition and Irradiation on the Glassy State Transition of Methyl Methacrylate-Styrene Copolymers.

Control number	Agency	Participant	Date	Duration	Amount
NsG-26-59	Stanford Research Institute International symposium on high temperature technology.	Nevin K. Hiester	June 1959	1 month	$4,000

Reports Received to Date on This Investigation

Hiester, Nevin K. (comp.): Advance papers of an international symposium on High Temperature Technology.

Control number	Agency	Participant	Date	Duration	Amount
NASw-72	Marlin-Rockwell Corp Investigation of methods for reducing the amount of end fiber in bearing components and of the effect of the reduction on the life of bearings and bearing balls.	Irwin	June 1959	12 months	$39,521
NASw-74	T. R. Finn & Co Investigation of techniques for the fabrication and coating of columbium, molybdenum, tantalum, tungsten, beryllium and their alloys.	C. W. Brunstetter	do	do	99,134
NASw-101	Battelle Memorial Institute Investigation of the influence of impurity elements, structure and prestrain on the tensile transition temperature of chromium (technical representative, R. H. Raring).	R. I. Jaffee	September 1959	do	35,630
NsG-38-60	Rensselaer Polytechnic Institute Investigation of the mechanism of strengthening a metal matrix by a finely dispersed insoluble second phase (continuation of NAw-6538).	F. V. Lenel	July 1959	24 months	60,190

RESEARCH GRANTS AND CONTRACTS OF NASA—Continued

ENGINEERING SCIENCES—Continued

Reports Received to Date on This Investigation

Ansell, G. S., and Lenel, F. V.: Criteria for Yielding of Dispersion-Strengthened Alloys.

MECHANICS

Control number	Agency	Participant	Date	Duration	Amount
NAw-6556	University of Washington Investigation of the stability (snap through) of conical shells subjected to lateral loads.	Dill	Sept. 11, 1958	12 months (Fiscal Year).	$4,644 500
S59-60	National Bureau of Standards Investigation of creep deflection of structures including an investigation of torsional creep of tubes at elevated temperatures (continuation S58-60).		October 1958	1 year	25,400
NAw-6557	University of Michigan Investigation of the use of differential analyzer representations in studying a structural dynamics of plates, rings, stiffened cylindrical shells and beams.	Howe	Sept. 11, 1958	12 months	18,630

Reports Received to Date on This Investigation

Albrecht, Rudolf F.: Approximation to the Solution of Partial Differential-Equations by the Solutions of Ordinary Differential-Equations.

Control number	Agency	Participant	Date	Duration	Amount
NAw-6559	University of Michigan Investigation of the vibration and flutter of buckled panels of finite aspect ratio.	Masur and Eisley	Sept. 22, 1958	12 months	$19,570
NASw-14	Pennsylvania State University Theoretical investigation of stress penetration waves and impact damage in plates.	Davids	Dec. 11, 1958	do	15,450
NASw-39	Iowa State College Thermal stresses in circular discs (continuation of NAw-6527).	Murphy	Apr. 1, 1959	3½ months	2,900
NsG-16-59	University of Florida Investigation of the theory of the general instability of stiffened cylindrical shells.	William A. Nash	May 1959	3 years	64,330
NsG-18-59	California Institute of Technology Investigation of cylindrical and conical shells with large radius to thickness ratios.	E. E. Sechler	do	do	108,000
NsG-17-59	New York University Investigation of the axial and bending general instability of stiffened circular cylinders.	George Gerard	do	do	120,000
NsG-27-59	University of Michigan Investigation of the natural vibration characteristics of twisted rotating blades in combined bending and torsion (continuation of Naw-6529).	G. Isakson	July 1959	12 months	16,822

Reports Received to Date on This Investigation

of twisted rotating blades in combined bending and torsion (continuation of NAw–6529).

Reports Received to Date on This Investigation

Isakson, G., and Eisley, J. G.: Natural Frequencies in Bending of Twisted Rotating and Nonrotating Blades.

SYSTEM ANALYSIS AND CONTROL

Control number	Agency	Participant	Date	Duration	Amount
NAw–6555	Stanford University Investigation of third order nonlinear control systems, including studies of the operation of quasi optimum control systems and of the effects of imperfections in the systems on their operation (continuation NAw–6533).	Flügge-Lotz	Sept. 11, 1958	15 months	$15,500

Reports Received to Date on This Investigation

Flügge-Lotz, Irmgard: Synthesis of Third-Order Contactor Control Systems.

Flügge-Lotz, Irmgard, and Ishikawa, Tomo: Investigation of Third-Order Contactor Control Systems.

Flügge, Lotz, Irmgard, Taylor, C. F., and Lindberg, Herbert E.: Investigation of a Nonlinear Control System. NACA representative 1391, 1958.

Flügge-Lotz, Irmgard, and Lindberg, Herbert E.: Studies of Second- and Third-Order Contactor Control Systems.

[Grants=NsG; contracts=NAw or NASw; those lacking prefix are recommended for award, but not yet awarded]

Control number	Agency	Participant	Date	Duration	Amount
NsG–14–59	Rensselaer Polytechnic Institute Investigation of the synthesis of high order nonlinear control systems with time input, including consideration of type input, multiple nonlinear system, form, and accuracy of the synthesis (technical representative, B. Maggin).	Chi-Neng Shen	May 1959	36 months	$84,384
NsG–28–59	Purdue University Investigation of linear and nonlinear control theory having applications to missiles and satellites.	R. Oldenburger	July 1959	36 months	200,262
NsG–36–60	Case Institute of Technology Investigation of the use of hybrid numerical circuits in closed-loop control systems (technical representative, Bernard Maggin).	H. W. Mergler	August 1959	do	178,040
	RECOMMENDED FOR AWARD SINCE LAST REPORT				
NsG–47–60	Stanford University Theoretical and experimental investigation of higher order nonlinear control systems, including investigation of "quasi optimum" control systems (continuation of NAw–6555).	Irmgard Flugge-Lotz	April 1960	12 months	18,700

RESEARCH GRANTS AND CONTRACTS OF NASA—Continued

SOCIO-ECONOMIC STUDIES

Control number	Agency	Participant	Date	Duration	Amount
NASw-91	Rand Corp. Investigation to identify national objectives of non-military space activities, suggest the magnitude and scope of effort required to attain these objectives and determine balance of emphasis of the program. (technical representative J. C. Oppenheimer).		June 1959	1 month	$26,878
NASw-105	University of Utah Predicting success in scientific laboratories from biographical information.	C. W. Taylor	July 1959	15 months	14,940
NASw-96	Brookings Institution Design of a comprehensive and long-term program of research and study regarding the social, economic, political, legal and international implications of the use of space for peaceful and scientific purposes.		December 1959	12 months	96,000

SCIENTIFIC INVESTIGATION IN SPACE

SOUNDING ROCKETS

Control number	Agency	Participant	Date	Duration	Amount
NASw-4	University of Michigan Investigation for development of rocket instrumentation packages for measuring the properties of the upper atmosphere.	Jones	Oct. 27, 1958	12 months	$175,000
NASw-31	New York University Investigation of the neutrons produced by cosmic radiation at high altitudes, including the instrumentation of two Aerobee-Hi rockets to be flown by the NASA (technical representative, Dr. Meredith).	Korff and Haymes	April 1959	24 months	98,000
NsG-32-60	University of Rochester Investigation of far ultra-violet and soft X-ray astronomy.	Malcolm P. Savedoff	September 1959	12 months	25,000
NsG-33-60	University New Hampshire Further investigation of the equatorial electrojet.	L. J. Cahill, Jr.	July 1959	18 months	45,600
NASw-115	University of Michigan Rocket grenade instrumentation program.	H. F. Allen	September 1959	24 months	300,000

EARTH SATELLITES

Control number	Agency	Participant	Date	Duration	Amount

Control number	Agency	Participant	Date	Duration	Amount
NASw-24	University of Chicago Design and building of an instrument to measure the composition and energy spectrum of the primary cosmic radiation.		Feb. 2, 1959	13 months	$300,280
NASw-33	Massachusetts Institute of Technology Preliminary investigation of the satellite gravitational reshift experiment, including performance comparisons of cesium frequency standards and comparions at cesium units with the NBS rubidium clock.	J. R. Zacharias	Mar. 20, 1959	6 months	50,000
NASw-17	State University of Iowa Space probe instrumentation to determine the components of the great radiation belt and the analysis of radiation observations made with satellites.	James A. Van Allen	Apr. 1, 1959	16 months	311,420
NASw-37-59	Massachusetts Institute of Technology Designing, constructing and testing a high-energy gamma ray detector capable of being carried in a satellite (technical representatives, Dr. Nancy Roman and J. E. Kupperian).	W. L. Krausbaer	April 1959	6½ months	68,000
NASw-54	University of Michigan Preliminary investigation of instrumentation suitable for measuring the intensity of radio noise levels above the ionosphere and to measure the dynamic spectra of solar radio bursts.	F. T. Haddock	do	12 months	81,600
NASw-55	University of Michigan Preliminary investigation of techniques and instrumentation for measurement of the ultraviolet solar emission spectrum (technical representative, Dr. J. E. Kupperian).	Leo Goldberg	Apr. 15, 1959	do	76,000
NASw-56	University of Minnesota Development and construction of instrumentation to measure directly in space the flux and specific ionization of cosmic rays and radiation-belt particles, including installation of such instrumentation in three space vehicles.	Winckler	April 1959	15 months	74,951
NASw-59	University of North Carolina Development and use of a precision coincidence telescope for study of primary cosmic radiation.	E. D. Palmatier	do	18 months	63,140
NASw-66	University of Wisconsin Stellar spectra-photometry in the far ultraviolet, including preliminary design studies of a satellite-borne telescope and consideration of data recovery and processing problems.	A. D. Code	May 1959	12 months	62,641
HS-168	Pennsylvania State University Investigation of ionospheric properties from satellite frequency observations at spaced locations.	W. J. Ross	do	do	37,169
NsG-7-59	Smithsonian Institution Scientific and engineering study for instrumenting an orbiting telescope.	Dr. F. L. Whipple	do	3 months	99,935
NsG-24-59	University of Illinois Investigation of the ionosphere using signals from earth satellites.	S. W. Swenson, Jr	July 1959	12 months	64,800

RESEARCH GRANTS AND CONTRACTS OF NASA—Continued

SCIENTIFIC INVESTIGATIONS IN SPACE—Continued

Reports Received to Date on This Investigation

Wyatt, Stanley P.: Solar Effects in the Motion of Vanguard.

Control number	Agency	Participant	Date	Duration	Amount
NsG-25-59	University of Arizona Investigation of telemetry, coding, and data processing requirements for the orbiting observatories project.	E. L. Morrison	July 1959	12 months	$24,917
NsG-30-60	Stanford University Investigation of ionospheric electron content and long range radio propagation.	O. K. Garriott	do	do	91,620
NASw-89	University of Colorado Study of solar ultraviolet radiation.	W. A. Rense	August 1959	do	110,600
NASw-107	University of Rochester Investigation of solid state photodetectors.	R. E. Hopkins	do	do	123,000
NASw-99	University of New Mexico Investigation of high-energy gamma-radiation in the primary cosmic radiation by satellite measurements.	Christopher P. Leavitt	September 1959	do	31,760
	RECOMMENDED FOR AWARD SINCE LAST REPORT				
NASw-80	Stanford Research Institute Investigation of electronic, ionic, and atomic impact phenomena.	C. J. Cook	October 1959	do	48,000
	University of Illinois Experiment to determine the effect of auroral on radio signals from satellites.	G. W. Swenson, Jr.		3 months	11,073

LUNAR PROBES

Control number	Agency	Participant	Date	Duration	Amount
NTF-6	Naval Research Laboratory Investigation of the radio activity of the moon by means of anticoincidence gamma and beta counters.	H. Friedman	June 1959		$150,000
NASw-81	California Institute of Technology Investigation of the moon with a lunar seismograph station (technical representatives, Dr. Jastrow, N. W. Cunningham and Dr. N. G. Roman).	H. Benioff and F. Press	do	48 months	125,000
NASw-82	Columbia University (Lamont Laboratory) Investigation of a lunar seismograph system (technical representative, Dr. Robert Jastrow).	Ewing, Oliver	July 1959	do	125,000
NsG-97-60	University of Chicago Ground-based lunar studies (technical representative, Dr. Nancy G. Roman).	G. P. Kuiper	August 1959	13 months	67,630

Control number	Agency	Participant	Date	Duration	Amount
	Ground-based lunar studies (technical representative, Dr. Nancy G. Roman).				

DEEP-SPACE PROBES

Control number	Agency	Participant	Date	Duration	Amount
NsG–19–59	Yale University Investigation of the feasibility of remote detection of bacteria by automatic observation of changes in exposed culture media.	Wolf Vishniac	June 1959	12 months	4,485
NsG–23–59	Pennsylvania State University Investigation of the helium contents of meteorites technical representative, Dr. Nancy G. Roman).	Carl A. Bauer	do	do	10,042
NASw–75	Massachusetts Institute of Technology Investigation of plasma densities and motions within the solar system.	B. Rossi	do	do	97,200

SATELLITE APPLICATIONS INVESTIGATIONS

Control number	Agency	Participant	Date	Duration	Amount
NASw–65	University of Wisconsin Preparation of machine programs for automatic reduction and analysis of data from meteorological satellites.	V. E. Suomi	June 1959	12 months	$59,050

SPACE OPERATIONS TECHNOLOGY

MANNED SPACE FLIGHT

Control number	Agency	Participant	Date	Duration	Amount
NASw–70	University of Minnesota Initiate prototype development for a photosynthetic gas exchanger and a non-CO_2 waste stabilizer for use in space vehicles (technical representative assigned; Dr. Worf).	Brown, Ishbin & Tsuchiya	June 1959	12 months	$60,000

RESEARCH GRANTS AND CONTRACTS OF NASA—Continued

SUPPORTING ACTIVITIES

TRACKING AND DATA ACQUISITION

Control number	Agency	Participant	Date	Duration	Amount
NsG–45–60	University of Heidelberg Operation of telemetry receiving station for composite radiation satellite, payload 16.	O. Hazel			$5,435
NASw–68	University of Manchester Tracking data from space probes.		April 1959	12½	179,200
NASw–88	George Washington University A study of and reduction of data from telemetry records.		July 1959	12½	32,475
NASw–122	Emory University Investigation of the effects of space flight conditions.	G. A. Brecher		do	2,185
NTF–58	Naval Ordnance Test Station Optical materials for selective ultra-violet transmission.	A. L. Olsen and W. R. McBride			25,000
NTF–74	University California Biological systems in interplanetary environment.				85,000
NsG–52–60	Stanford University Investigation of convection heat transfer in annular passages.	W. M. Kays, W. C. Reynolds		24 months	72,607
NsG–51–60	Smithsonian Institute Study of instrumenting an orbiting telescope (continuation NsG–7–59).	F. L. Whipple		7½ months	199,927
NASw–95	Electric Boat Study of problems relating to a closed cycle photosynthetic gas exchanger suitable for space craft.	H. E. Sheets		12 months	118,421
NASw–90	MSA Research Corp Investigation of potassium and sodium superoxide.			12 months	73,386
NASw–50	Convair Study and design of radiation shielding for manned space.			do	23,730
NASw–117	ISOMET Corp Develop system for obtaining O_2 from CO_2.				35,000
NASw–127	General Electric Purification of water from biological waste.				35,000

ADDITIONAL GRANTS AND CONTRACTS IN BASIC RESEARCH IN SPACE SCIENCES NOT INCLUDED ON LISTING OF NOV. 1, OF OFFICE OF RESEARCH GRANTS AND CONTRACTS

Control No.	Agency	Participant	Title, description	Date	Duration	Amount
NTF 37	CRPL	Knecht, Allen	Study of topside sounder for ionosphere	Mar. 9, 1959	2 months	$15,000
NTF 44	U.S. Coast and Geodetic Survey.		Modifications and improvements for facilities to test weak magnetic field measuring instruments.	Apr. 9, 1959	9 months	27,000
NASw-78	Geotechniques		Study of the feasibility and practicability of photogrammetric mapping of the moon and other extraterrestrial bodies.	June 15, 1959	3 months	15,000
NASw-25	ITEK Corp		Model atmosphere studies, such as winds and diffusion	Feb. 11, 1959	12 months	607,250
NASw-98	do	J. X. Cousins	Electron density in the atmosphere	June 9, 1959	do	116,878
NsG 30	Stanford University	Garriott	Ionospheric research utilizing satellite	July 20, 1959	do	91,620
NTF 58	U.S. Naval Ordnance Test Lab.		Optical materials for selective ultraviolet transmission filters	July 9, 1959	do	25,000
NTF 62	ABMA	Young	Biosatellite experiments	June 3, 1959	do	20,000
NTF 11	NRL	H. Friedman	Design and construction of satellite flight packages for survey of wavelength region from 0.05–12,000 A.	June 29, 1959	do	100,000
NASw-99	University of New Mexico	Leavitt	Gamma ray spectrometry; measurements of high energy radiation in the primary cosmic radiation by means of satellites.	July 29, 1959	do	31,760
NASw-89	University of Colorado	Rense	Solar ultraviolet radiation studies from rocket and satellite flights.	Aug. 1, 1959	do	110,600
NASw-107	University of Rochester	Stewart	Research on solid state photodetectors	Aug. 17, 1959	do	123,000
NsG 32-60	do	Savedoff	Far ultraviolet and X-ray astronomy	Sept. 11, 1959		25,000
NsG-25-59	University of Arizona	Morrison	Investigation of remote operation of astronomical telescope	June 25, 1959	12 months	24,917
NASw-62	Hughes Aircraft		Design and construction of Ammonia Beam Maser and associated dividing circuitry.	June 1, 1959	do	200,000
NASw-100	IRCO Corp	Jones	Lightweight low-cost telescope objective mirrors for balloon and space use.	Aug. 1, 1959	6 months	29,960
NASw-124	Geophysica Corp. of America.	Marmo	Laboratory and theoretical studies in the vacuum ultraviolet.		10 months	153,473
NASw-133	University of Michigan		Experiment to measure the pressure of the lunar atmosphere		4 months after launch date.	50,000
NASw-135	Chicago Midway Laboratories.		Explorer VI data reduction and analysis	Nov. 13, 1959	7 months	39,775
NTF-9	GSFC	Heppner	Procurement of a lunar data conversion and recording system.	June 30, 1959		75,000
NTF-10	Edgerton Germeshausen and Grier.	GSFC-Mazur	Preliminary design study for flashing light system	do	1 month	19,650
NTF-33	NBS	Bender	Development of RB vapor frequency standards	Jan. 2, 1959	12 months	272,100
NTF-42	University of Minnesota	Ney	Experiment on the polarization of the solar corona	Apr. 6, 1959	9 months	40,000
NTF-56	AOMC		Recovery package for nuclear emulsions	July 6, 1959		2,000
NTF-83	NBS		Ionospheric studies using satellite beacon transmitters	Oct. 12, 1959	12 months	132,900
NTF-84	NBS		Ionospheric electron density data	Nov. 23, 1959	do	100,000

ADDITIONAL GRANTS AND CONTRACTS IN BASIC RESEARCH IN SPACE SCIENCES NOT INCLUDED ON LISTING OF NOV. 1, OF OFFICE OF RESEARCH GRANTS AND CONTRACTS—Continued

Control No.	Agency	Participant	Title, description	Date	Duration	Amount
HS–434	U.S. Weather Bureau		Equipment and supplies to provide temporary recording stations for Explorer VII at 5 existing weather stations.			$50,000
HS–474	Geophysics Corp. of America.		Study of winds, diffusion, and expansion of gases in the upper atmosphere extension of NASw–25.		1 year	256,582
HS–463	IRCO Corp	Jones	Investigation of membrane-type telescope mirrors for space use; extension of NASw–100.		3 months	14,980
HS–450	California Institute of Technology.		Lunar and planetary studies		12 months	115,000
HS–381	LaCoste and Romberg	LaCoste	Development of gravity meter		do	55,000
HS–414	Princeton University	Schwarzschild	Support of the use of television techniques with telescopes above the atmosphere.		do	110,000
HS–438	Rand Corp	Vestine	Study of charged particles and fields in space		18 months	141,441
HS–446	University of Auckland		Radio propagation study		12 months	7,000

1961 NASA AUTHORIZATION

THURSDAY, FEBRUARY 18, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE NO. 3,
Washington, D.C.

The subcommittee met at 2 p.m., Hon. David S. King presiding.

Mr. KING. Let the record show that Subcommittee No. 3 of the Committee on Science and Astronautics is called to order for the purpose of receiving testimony and giving consideration to the salaries and expenses portion of the proposed NASA budget for fiscal 1961, and other related matters.

The subcommittee has as its witnesses this afternoon, and we welcome you here and appreciate your attendance, Wesley L. Hjornevik, also Ralph E. Ulmer, Budget Officer, who has been with us before, Dr. Newell, who has been with us before, and Richard V. Rhode, who has also been with us and gave some excellent testimony last Monday, as I recall.

Mr. Hjornevik, would you like to proceed with your statement?

Mr. HJORNEVIK. Yes, Mr. Chairman.

(Discussion off the record.)

STATEMENT OF WESLEY L. HJORNEVIK, DEPUTY DIRECTOR, OFFICE OF BUSINESS ADMINISTRATION; ACCOMPANIED BY RALPH E. ULMER, BUDGET OFFICER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. HJORNEVIK. Mr. Chairman, the salaries and expenses appropriation provides for the cost of salaries and certain operating expenses of the field and headquarters establishments of the National Aeronautics and Space Administration.

The estimates provide for a headquarters complement of 683 people, a field complement of 15,690. Of this complement, 7,812 are proposed for the four aeronautical and space research centers, that is the Langley, Ames, and Lewis Centers, and the Flight Research Center; the estimates propose that the employment levels for these particular centers be maintained at the current 1960 level.

An additional 7,800 employees are proposed for the space flight development centers, 2,000 of these at the Goddard Space Flight Center, currently under construction out near Beltsville, 300 at the Wallops Station, and 5,500 at the Huntsville Center which is proposed for transfer to NASA from the Army.

52493—60——14

The remaining 78 employees are located in our western operations office at the Atlantic Missile Range and at the Pacific Missile Range.

The major increases are requested for additional staffing at Goddard and Wallops and to cover the cost of the 5,500 people at the Huntsville Center who are reflected in the NASA budget for the first time in 1961.

The major increase in staffing of the organizational units which are presently a part of NASA relate to the continued staffing of the Goddard Center, for which facilities are currently under construction.

We propose to increase this center from 1,200 in 1960 to 2,000 in 1961. It is anticipated that in subsequent years the staffing of this center will continue to increase to in the neighborhood of 2,400 to 2,500 people.

This Center, together with the Jet Propulsion Laboratory, operated under contract with the California Institute of Technology, constitutes the two NASA resources for conceiving, organizing, and managing the creation of payloads for NASA's flight program.

The Goddard Center is primarily concerned with earth satellites and sounding rocket programs, while JPL is concentrating on lunar and interplanetary space exploration.

The total staffing of the NASA Huntsville Center is approximately the same capability that Dr. von Braun had available to him under Army management.

The requirements for travel, communication, power, printing, et cetera, are generally related to the numbers of people involved in each of these centers and to the program requirements that arise out of each center.

Now, we have on a chart over here the same employment figures which I have just run through briefly for you and the total dollars involved in the S. & E. appropriation for each of them and our total request of $170.7 million.

Mr. FULTON. Mr. Chairman, at this point, I ask unanimous consent that the chart be placed in the record.

Mr. KING. Without objection, it is so ordered.

NASA fiscal year 1961 budget, salaries and expenses

	Number of employees at end of year	Requested
NASA Headquarters, Washington, D.C.	683	$9,890,000
Langley Research Center, Va.	3,220	29,295,000
Ames Research Center, Calif.	1,440	15,244,000
Lewis Research Center, Ohio	2,736	25,724,000
Flight Research Center, Calif.	416	3,679,000
Goddard Space Flight Center, Md.	2,000	25,084,000
Wallops Station, Va.	300	2,678,000
NASA Huntsville Facility, Ala.	5,500	58,313,000
Liaison various locations	78	853,000
Total	16,373	170,760,000

Mr. BERESFORD. Is there such a chart in this budget book?

Mr. ULMER. No. We will make a copy available. Page 9 of the big book has a similar chart. It shows all 3 years.

(Discussion off the record.)

Mr. FULTON. I ask that page 9 of the budget book be furnished for the record.

Mr. ULMER. It is available to the committee.

Mr. KING. You requested that it go into the record.

Without objection, it will.

Summary, salaries and expenses, fiscal year 1961 estimates

	Number of employees at end of fiscal year			Appropriations		
	1959 actual	1960 estimated	1961 estimated	1959 actual	1960 actual	1961 requested
NASA headquarters	428	683	683	$5,538,860	$7,549,300	$9,890,000
Langley Center	3,297	3,220	3,220	30,568,970	27,445,500	29,295,000
Ames Center	1,478	1,440	1,440	16,299,035	14,257,050	15,244,000
Lewis Center	2,783	2,736	2,736	27,215,227	24,840,200	25,724,000
Flight Center	336	416	416	3,154,208	3,038,150	3,679,000
Goddard Center	782	1,214	2,000	2,021,100	11,802,270	25,084,000
Wallops Station	171	225	300	1,356,820	1,700,100	2,678,000
NASA Huntsville		100	5,500		227,000	58,313,000
Western Office	7	32	46	94,815	338,930	515,500
AMRO Office	4	20	26	20,000	201,500	278,000
PMRO Office			6			59,500
Wright Office				17,265		
Total	9,286	10,086	16,373	86,286,300	91,400,000	170,760,000

Mr. FULTON. One other thing. Why don't you have a better breakdown of the kinds of employees? Are you going to do that?

Mr. HJORNEVIK. We can provide this, if you wish.

Mr. FULTON. I think you ought to have a better breakdown. You see, your maintenance, your supporting employees, a breakdown of that type.

Mr. ULMER. We will be glad to supply that information for the record.

To give you just a very brief picture if I may, approximately 25 percent of those numbers are what we call research scientists and engineers. The balance are supporting technical people, supporting wage board employees, and administrative employees.

On an average, about 40 percent of the employees are in the wage board category.

Mr. FULTON. If you will submit it for the record that would be a good breakdown.

Mr. ULMER. Surely.

Distribution of NASA Personnel

(December 31, 1959)

	Percent
Research, scientists and engineers	27
Supporting technicians	16
Wage board	39
Administrative and clerical	18
Total	100

Mr. KING. By way of information, have you finished with your prepared statement?

Mr. HJORNEVIK. I was about to say just one more thing.

Mr. FULTON. I wanted to get it before we got off this particular subject.

Mr. BERESFORD. I think it would be well for the subcommittee to have an up-to-date list of all NASA positions above GS–15—we did get one about a year ago—including the names and titles of the incumbents and their present rates of compensation.

Mr. ULMER. Mr. Beresford, this was requested in yesterday afternoon's hearing and presumably will appear in that record.

Mr. BERESFORD. Do you also have such a list for the ABMA, Development Operations Division?

Mr. ULMER. Yes, sir.

Mr. BERESFORD. It would be helpful if you could supply that.

Mr. ULMER. Yes, sir.

List of positions above GS–15 in the ABMA Development Operations Division

(February 15, 1960)

Incumbent	Position title	Grade	Salary
Von Braun, Wernher	Director, Development Operations Division	Excepted	$19,000
Rees, Eberhard F. M.	Deputy Director, Development Operations Division	do	18,500
Haeussermann, W	Director, Guidance and Control Laboratory	do	18,000
Debus, Kurt H	Director, Missile Firing Laboratory	do	18,000
Geissler, Ernst D	Director, Aeroballistics Laboratory	do	18,000
Hoelzer, Helmut	Director, Computation Laboratory	do	17,500
Mrazek, William A	Director, Structures and Mechanics Laboratory	do	18,000
Stuhlinger, Ernst	Director, Research Projects Laboratory	do	18,000
Rudolph, Arthur	Project Director, Redstone and Pershing	do	18,000
Mueller, Fritz	Deputy Director, Guidance and Control Laboratory	do	17,500
Heimburg, Karl L	Director, Test Laboratory	do	17,500
Maus, Hans H	Director, Fabrication and Assembly Engineering Laboratory	do	17,500
Neubert, Erich W	Director, Systems Analysis and Reliability Laboratory	do	17,500
Hueter, Hans H	Director, Systems Support Equipment Laboratory	GS–18	17,500
Dannenberg, Konrad	Project Director, Jupiter	GS–17	15,615
Weidner, Hermann K	Deputy Director, Structures and Mechanics Laboratory	do	15,615
Hoberg, Otto A	Chief, Missile Instrumentation Development Branch (Guidance and Control Laboratory).	do	16,615
Gruene, Hans F	Deputy Director, Missile Firing Laboratory	do	15,375
Lange, Oswald H	Director, space programs	do	15,375

Mr. FULTON. As a matter of fact, on that end of it, while we are getting the charts together, I would show what the ABMA was before it came over and then what you are getting and what remains.

I would even give the personnel transfer figures on that, if you could.

Mr. ULMER. We will be able to give those in estimate form. As you know, the actual transfer hasn't taken place.

Mr. FULTON. I realize that. But you are really giving us a pro forma of that transfer, what it means?

Mr. ULMER. Correct, be glad to.

Personnel adjustments pursuant to transfer of ABMA Development Operations Division to NASA

	AOMC present strength (approx.)	To be retained by AOMC	Transfer to NASA	Additional recruiting by NASA	Total NASA
Government employees	4,200	350	3,850	1,300	5,150
Enlisted military personnel	264	264			
Contractor employees	869	519	350		350
Total	5,333	1,133	4,200	1,300	5,500

Distribution of NASA Huntsville facility personnel

	Transfer from Development Operations Division, ABMA	Additional recruiting by NASA	Total
Research scientists and engineers	1,353		1,353
Supporting technicians	642	150	792
Wage board	1,791	450	2,241
Administrative and clerical	414	700	1,114
Total	4,200	1,300	5,500

Mr. FULTON. Then if you remember, I had asked for what extra slots you might need.

Mr. ULMER. That matter is under study by Dr. Glennan at the moment.

Mr. FULTON. I think you ought to get those requirements for us. I talked yesterday evening with Abe Silverstein and suggested he get them up promptly so that we might include them here in the authorization.

Mr. KING. Would you like to finish?

Mr. HJORNEVIK. With this brief summary, we are prepared to answer any questions the committee may have on any part of the requirements.

Mr. KING. I have a few questions. I know Mr. Fulton has several.

(Discussion off the record.)

Mr. ULMER. We can supply a very broad-brush answer to your question, Mr. Fulton, but, for example, at the research centers, Langley, Ames, and Lewis, and the flight center, these people are working on literally hundreds of programs and this becomes a very difficult and time-consuming task to give you the assignments against each of the research authorizations.

Mr. FULTON. I don't think that is necessary.

Mr. ULMER. But we can give a broad-brush cut against programs.

Mr. FULTON. I think that is sufficient.

Analysis of research effort at Langley, Ames, Lewis, and Flight Research Centers, fiscal years 1960 and 1961

Program	Percent of total effort	
	1960	1961
Advanced aeronautical research:		
Aerodynamics	13.9	11.9
Aeronautical propulsion technology	3.6	3.1
Aeronautical structures and materials technology	10.7	9.3
Operations and environment	8.5	7.2
Space research:		
Space flight mechanics	9.8	12.6
Space propulsion technology	22.3	22.2
Space structures and materials technology	15.5	18.3
Spacecraft aerodynamics	15.7	15.4
Total	100.0	100.0

Mr. KING. In a few words, could you state what the item "Expenses" covers?

Mr. ULMER. Mr. King, the item, "Expenses" covers everything in the salaries and expenses appropriation, other than salaries. The major items are the "Travel expenses," the "Rents and utilities" item, and the retirement contribution of the agency to the Civil Service Commission.

On page 8 we have a breakdown of the items. Of the total of $170,760,000 being requested for "Salaries and expenses," 128.6 million is for salaries; 5.8 million for travel; $23.8 million for rents and utilities, and this latter account includes the electric power for operation of our large wind tunnels and other research facilities, $7.6 million for contributions to the retirement account, and $2.5 million for life insurance, health insurance, and security investigations.

Those are the major items. There are some smaller items involved in transportation of household goods and in the printing and reproduction account.

Mr. KING. Those are included in expenses?

Mr. ULMER. That describes what the word "expenses" means.

Mr. KING. Now, on your chart, your items there are on a geographical basis, aren't they?

Mr. ULMER. Correct, sir.

Mr. KING. Except possibly the last one.

Mr. ULMER. All of them are on a geographical basis. The last item is simply a grouping of several of the smaller offices.

Mr. KING. How do you handle those items which are unrelated to any geographical area, or are they all related?

Mr. ULMER. Each geographical area is involved in nearly every one of these expense items. Just as an example, the retirement contribution is involved in any area where you have people, because it is simply a percentage calculation on the basis of the salary.

Mr. KING. What about travel?

Mr. ULMER. The travel again is budgeted and controlled on the basis of where the people exist, where their official duty station is.

Mr. KING. So that every item which you have denominated salary and/or expense can be related to one of the geographical areas referred to one the chart?

Mr. ULMER. That is generally correct. There may be some exceptions: printing and reproduction, for example.

Mr. KING. Now, you have in the first column the number of employees. In many cases the present number would not coincide with the number indicated. The chart takes into account the anticipated expansion of personnel, is that correct?

Mr. ULMER. Correct, sir.

Mr. HJORNEVIK. The expansion, however, is limited to the Goddard Space Flight Center, the Wallops Station and I think a few in the various locations.

Mr. KING. Do you mean that in the other items that you did not just mention there is no anticipated expansion?

Mr. HJORNEVIK. That is correct.

Mr. KING. The personnel will remain constant through fiscal year 1961, is that right?

Mr. ULMER. That is correct, with this one modification: The President's budget document, by virtue of the requirements in preparing

that document, will actually show the Huntsville activity as an increase, simply because the funding for that activity is carried under the Department of Defense budget in 1960; we pick it up in 1961.

So that in the mechanics of preparing the supporting details the Huntsville activity does show as an increase for NASA, but in another phase of the President's budget, it shows as a deduction for DOD. So in that sense, governmentwise, the 5,500 is not an increase even though specifically in our budget it shows as an increase. Do you follow me?

Mr. KING. I don't understand your saying it is not an increase.

Mr. ULMER. Governmentwise; it shows as a deduction for DOD, and as an increase for NASA which is a net of zero, but in our specific section of the President's budget, we are going from 10,000-some people to 16,373, and the biggest part of that increase is the 5,500 for Huntsville.

Mr. KING. Is that indicated on your chart?

Mr. ULMER. Second line from the bottom, Mr. King, the 5,500 people.

Mr. KING. Yes, that is $58 million plus.

Mr. ULMER. Yes, sir.

Mr. KING. Mr. Fulton?

Mr. FULTON. That $58,313,000 is not the total, because there is funded under research and development $18,752,000, so the total really comes out $77,065,000?

(Discussion off the record.)

Mr. FULTON. Both sides join in making the request that we have the details of the fiscal year 1961 estimates of personal services, analysis by location, analysis of positions and costs.

The fiscal year 1961 estimates on data on personal services with the number of employees at the end of the fiscal years 1959, 1960, 1961, both actual and/or estimated, and the obligations for personal services for the same years.

We would ask for a summary analysis of personal services with statements of authorized end of year employment in the years 1959, and 1960, and 1961, also.

We would like to have set out, especially, the within-grade salary advancements, and the new positions and the regular and new position lapses, as well as within-grade lapses.

We would like to have the overtime and holiday pay set out for each of these years, as well as the nightwork differential and any items of personal services.

Then we would like on the item of travel, analysis by location and analysis by types of travel.

We would like to have the transportation of supplies, equipments, household goods, personal effects, and items of all kinds set out by location as well as by types of transportation.

On communication services we would like to have the fiscal year obligations for 1959, fiscal year 1960 and 1961 estimates, with an analysis by location and analysis by types of service.

Also we would like to have the figure that is funded under the "Research and development" heading and not within "Salaries and expenses."

Please supply the committee with the complete analysis of rents and utility services, with the analysis divided by location as well as by types of rents and services.

We would like a definite statement as to what utilities, power, and services are to be supplied by the Department of Army for NASA-Huntsville, and please explain shortly, the contract for such types of supporting services.

There should be excluded, by the figure given, anything that is funded under "Research and development."

One of the items of expense the committee is particularly interested in is the rental cost of data reduction equipment. The committee requests that this be supplied in total for each of the fiscal years 1959, 1960, and 1961, and also that it be set out by location, or geographical area.

Please explain to the committee why the fiscal year obligation was $19,570 for miscellaneous rentals, while in fiscal year 1960, estimated, there is an increase to $156,600.

There should also be an explanation why the estimate for miscellaneous rentals for the fiscal year 1961 is then reduced to $84,600.

Mr. ULMER. Would you like me to speak on that now, sir or just put it in the record?

Mr. FULTON. Just in the record——

Mr. KING. No, I would like to hear the explanation.

Mr. ULMER. I do not have all the details, but if I can draw on my memory, the increase occurs in two areas, NASA headquarters and the western office. The 1960 increase comes about because of the need for renting some additional space in both areas.

In the 1961 budget for the western office this is a continuing need and the figure shows at the higher rate for 1961 as well as for 1960. At the headquarters office, at the time these estimates were prepared, it was our understanding that the rental cost would be mainly absorbed by GSA in 1961, and that is the reason there is a reduction.

I would like to check that, however, and give you all of the facts in the record if I may.

Justification of budget item for "Miscellaneous rentals"

The item for "Miscellaneous rentals" increases from $19,570 in the fiscal year 1959 to $156,600 in the fiscal year 1960 chiefly to cover the following three items:

1. Rental of 2 parcels of land now used by the Jet Propulsion Laboratory which NASA plans to obtain title to in the fiscal year 1961, Yearly rental (charged to NASA Headquarters)	$21,100
2. Rental of office space in the District of Columbia for approximately 3 months (charged to NASA Headquarters)	60,000
3. Full-year rental of office space for the Western Operations Office, Santa Monica, Calif. (charged to western office)	35,953
Total	117,053

The balance of the increase covers greater use of such items as rented motor vehicles, equipment, etc.

In the fiscal year 1961, the first two of the three items listed above will not be required, and the fiscal year 1961 estimates are reduced accordingly, as offset by some increase in use of rental equipment.

Mr. KING. All right, if you would do that.

Mr. FULTON. Shall I just go ahead?

Mr. KING. Yes.

Mr. FULTON. The committee would like to have the expenses of printing and reproduction analyzed by fiscal year 1959, fiscal year 1960, and fiscal year 1961, estimates and obligations. This analysis

should be supplied by location, as well as by analysis by types of printing.

When we examine the item, "Other contractual services," the committee finds that the total of all locations is $3,377,802 in 1959. We believe that this should be supplied under the headings of each fiscal year, 1959, 1960, and fiscal year 1961. We would like to have this supplied under analysis by location as well as analysis by type of services.

In the analysis by types of services, we would like to have set out the amounts that may be funded under "Research and development" that are not included in this particular heading upon which we are having the hearing. If you will supply that for informational purposes please.

The committee would like to have a short description of the Federal health program of employees. How about your pensions? Can you give us the pensions?

Mr. ULMER. This comes under object of expenditure 11, Mr. Fulton.

Mr. FULTON. Very well.

On services by other Government agencies, the committee would like to have the research services set out, security investigations, as well as incidental services. This subcommittee is given the specific jurisdiction of equipment.

Mr. ULMER. If I may interrupt, Mr. Fulton, the equipment is entirely funded under the "Research and development" appropriation.

Mr. FULTON. All right. I notice in 1960 and 1961 it is under that.

Mr. ULMER. Yes, sir.

Mr. FULTON. But it isn't in 1959?

Mr. ULMER. In 1959 we were operating with two appropriations, one made to the NACA, which was absorbed by NASA, and one made to NASA.

Under the NACA appropriation, all of our items, other than the construction of capital items was funded under a single "Salaries and expenses" appropriation. At the time the NASA appropriations structure was set up, items of equipment and supplies were removed and put into the no-year "Research and development" appropriation. So in 1959 we had a split situation, where we were operating with two appropriations. We are now on the basis of a single NASA appropriation structure.

Mr. FULTON. With the understanding it is being placed for fiscal year 1960 and 1961 under the title of "Research and development," could you give us those figures for comparison with fiscal year 1959?

Mr. ULMER. Yes, sir.

Mr. FULTON. The committee is interested in the calculation of Government contributions to the retirement fund and the status of the payments into this account.

We are also interested in cost of intermittent employment, overtime and holiday pay, night-work differential applicable to classified employees.

We would like to have a total for terminal leave payments as well as salaries, the amount of salaries subject to deductions for social security purposes.

The subcommittee would like to have—and I would like—an itemization of reimbursements for details of other Government organizations who have been lent to NASA. This should be done by fiscal year so that it will show the committee what the comparisons are between fiscal year figures.

The committee is interested in refunds, awards, and indemnities that might have been made in the fiscal years 1959 or estimated for the fiscal year 1960 and the fiscal year 1961. This analysis should be furnished by location and there also should be an analysis by types of awards and claims so that we can determine the respective amounts for incentive awards for employees as well as the payment of damages for tort claims.

I think there should be a fairly short paragraph on the respective tort claims of some size.

The committee is interested in the taxes and assessments that may have been paid by NASA.

We should have the Federal Government contribution to the social security payments of those employees who do not come under the retirement system. This analysis should be by location as well as analysis by types of taxes and assessments.

(Discussion off the record.)

Mr. FULTON. On these proposed estimates of authorization and appropriation, we would like to have a summary provided as set out by fiscal years 1959, fiscal year 1960, and fiscal 1961, showing total allotments with such a summary breakdown as you feel would be advisable to sho wthe overall method of reaching the totals.

Mr. ULMER. Very well, sir.

Mr. BERESFORD. You have that information.

Mr. ULMER. Yes, sir.

Mr. FULTON. These breakdowns should be both as to type of service as well as by geographical location, and facility, where possible.

Mr. ULMER. Yes, Mr. Fulton.

Mr. KING. Without objection, then, all of the items referred to by Mr. Fulton will be included in the record.

(The documents referred to are as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, FISCAL YEAR 1961 ESTIMATES

Appropriation summary

	Salaries and expenses	Research and development	Construction and equipment	Total
Approved, fiscal year 1959:				
Independent Offices Appropriation Act, 1959; Public Law 85-844	$78,100,000		$23,000,000	$101,100,000
Supplemental Appropriation Act, 1959; Public Law 85-766	5,000,000	$50,000,000	25,000,000	80,000,000
Second Supplemental Appropriation Act, 1959; Public Law 86-30	3,186,300			3,186,300
Transfers from DOD (72 Stat. 433)		154,619,532		154,619,532
Total	86,286,300	204,619,532	48,000,000	338,905,832
Approved, fiscal year 1960:				
Supplemental Appropriation Act, 1960; Public Law 86-213	91,400,000	335,350,000	73,825,000	500,575,000
Appropriation transfer; Public Law 86-213		−15,000,000	15,000,000	
Total	91,400,000	320,350,000	88,825,000	500,575,000
Requested, fiscal year 1960: Supplemental estimates		12,200,000	10,800,000	23,000,000
Requested, fiscal year 1961: Regular estimates	170,760,000	621,453,000	122,787,000	915,000,000

Summary, salaries and expenses, fiscal year 1961

	NASA Headquarters	Langley Center	Ames Center	Lewis Center	Flight Center	Goddard Center	Wallops Station	Huntsville Facility	Western Office	AMR Office	PMR Office	Total
Estimated end of year employment	683	3,220	1,440	2,736	416	2,000	300	5,500	46	26	6	16,373
	$5,936,774	$22,444,084	$10,518,547	$19,894,614	$2,936,752	$15,711,806	$1,925,284	$40,175,000	$419,605	$236,265	$48,000	$120,246,731
01 All personal services	6,200,000	22,609,000	10,650,000	20,101,000	3,120,000	15,834,000	1,915,000	47,540,000	393,000	226,000	37,000	128,625,000
02 Travel	1,100,000	460,000	160,000	300,000	135,000	2,210,000	150,000	1,281,000	25,000	18,000	10,000	5,849,000
03 Transportation	14,000	12,000	15,000	20,000	3,000	236,000	22,000	100,000	10,000	5,000	5,000	442,000
04 Communications	535,000	82,000	42,000	94,000	20,000	244,000	40,000	229,000	12,000	12,000	4,000	1,314,000
05 Rents and utilities:												
Electric power		2,592,000	2,612,000	2,405,000	14,000	75,000	145,000					7,843,000
Other utilities			125,000	435,000	15,000	25,000						600,000
Rentals	30,000	1,815,000	828,000	853,000	150,000	5,363,000	264,000	6,050,000	46,000			15,399,000
06 Printing	180,000	26,000	15,000	10,000	2,000	25,000	5,000	100,000				363,000
07 Contractual services:												
Life insurance	20,000	74,000	35,000	66,000	10,000	46,000	6,000	132,000	1,700	1,000	500	392,200
Health program	38,000	181,000	81,000	154,000	19,000	101,000	16,000	306,000	2,500	1,500	300	900,300
Security investigations	1,248,000											1,248,000
11 Retirement	384,000	1,441,000	677,000	1,283,000	188,000	919,000	114,000	2,570,000	25,300	14,500	2,700	7,618,500
13 Awards	140,000	1,000	1,000	1,000	1,000	2,000		1,000				147,000
15 Taxes	1,000	2,000	3,000	2,000	2,000	4,000	1,000	4,000				19,000
Total	9,890,000	29,295,000	15,244,000	25,724,000	3,679,000	25,084,000	2,678,000	58,313,000	515,500	278,000	59,500	170,760,000

01 Personnel services

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$2,471,433	$4,927,400	$6,200,000
Langley Center	22,183,397	22,482,200	22,609,000
Ames Center	10,236,443	10,566,200	10,650,000
Lewis Center	19,408,144	20,187,500	20,101,000
Flight Center	2,161,741	2,657,500	3,120,000
Goddard Center	2,734,824	9,471,250	15,828,000
Wallops Station	644,213	1,374,600	1,915,000
NASA Huntsville		212,000	47,540,000
Western Office	47,882	241,650	399,000
AMRO Office	14,682	160,500	226,000
PMRO Office			37,000
Wright Office	14,354		
Total, all locations	59,917,113	72,280,800	128,625,000
Funded under "Research and Development"	−1,171,993		
Total	58,745,120		
Analysis of positions and cost:			
End of year employment	9,286	10,086	16,373
Position lapses	−810	−401	−273
Average number of positions [1]	8,476	9,685	16,100
Annual cost of positions, end of year	$65,142,007	$73,254,506	$120,246,731
Lapses	−6,294,304	−3,328,066	−2,389,731
Net cost of positions	58,847,703	69,926,440	117,857,000
Intermittent employment	4,016	67,900	250,000
Regular pay above 52-week base	246,121	558,710	463,000
Overtime and holiday pay	620,874	1,361,000	9,087,000
Nightwork differential	155,514	169,300	451,000
Living and quarters allowances	4,952	10,000	20,000
Additional pay for service abroad	2,842	13,000	30,000
Uniform allowances	7,780	10,000	17,000
Payments to other agencies for reimbursable details	[2] 27,311	[2] 164,450	[2] 450,000
Total, all personal services	59,917,113	72,280,800	128,625,000

[1] Includes positions filled by military personnel.
[2] Statement of reimbursable details:

	1959	1960	1961
GSA guard service	$20,355		
CSC details	6,956	$64,450	$80,000
Military employees		100,000	370,000
Total	27,311	164,450	450,000

Data on personal services

	Number of employees at end of fiscal year			Obligations for personal services		
	1959 actual	1960 estimated	1961 estimated	1959 actual	1960 estimated	1961 estimated
NASA Headquarters	428	683	683	$2,471,433	$4,927,400	$6,200,000
Langley Center	3,297	3,220	3,220	22,183,397	22,482,200	22,609,000
Ames Center	1,478	1,440	1,440	10,236,443	10,566,200	10,650,000
Lewis Center	2,783	2,736	2,736	19,408,144	20,187,500	20,101,000
Flight Center	336	416	416	2,161,741	2,657,500	3,120,000
Goddard Center	782	1,214	2,000	2,734,824	9,471,250	15,834,000
Wallops Station	171	225	300	644,213	1,374,600	1,915,000
NASA Huntsville		100	5,500		212,000	47,540,000
Western Office	7	32	46	47,882	241,650	393,000
AMRO Office	4	20	26	14,682	160,500	226,000
PMRO Office			6			37,000
Wright Office				14,354		
Total	9,286	10,086	16,373	59,917,113	72,280,800	128,625,000

Summary analysis of personal services

	NASA Headquarters	Langley Center	Ames Center	Lewis Center	Flight Center	Goddard Center	Wallops Station	Huntsville Facility	Western office	Atlantic Missile Range office	Pacific Missile Range office	Total
1959												
Authorized end of year employment	465	3,300	1,490	2,783	336	827	172	----------	7	6	----------	9,386
	$3,990,356	$22,315,765	$10,375,505	$19,650,195	$2,339,130	$6,508,842	$1,000,971	----------	$64,455	$74,350	----------	$66,319,569
Actual end of year employment	428	3,297	1,478	2,783	336	782	171	----------	7	4	----------	9,286
	$3,678,369	$22,209,951	$10,374,891	$19,606,568	$2,316,670	$5,852,969	$986,974	----------	$64,455	$51,160	----------	$65,142,007
1960												
Estimated end of year employment	683	3,220	1,440	2,736	416	1,214	225	100	32	20	----------	10,086
	$5,861,774	$22,329,084	$10,458,547	$19,799,614	$2,921,952	$9,343,806	$1,319,974	$727,000	$305,605	$187,150	----------	$73,254,506
Net cost of positions	$4,683,100	$22,117,100	$10,389,850	$19,875,690	$2,482,000	$8,492,450	$1,288,100	$202,000	$238,350	$157,800	----------	$69,926,440
All other personal services	244,300	365,100	176,350	311,810	175,500	978,800	86,500	10,000	3,300	2,700	----------	2,354,360
Total personal services	4,927,400	22,482,200	10,566,200	20,187,500	2,657,500	9,471,250	1,374,600	212,000	241,650	160,500	----------	72,280,800
1961												
Within-grade salary advancements	$75,000	$115,000	$60,000	$95,000	$14,800	$80,000	$5,310	$190,000	$2,000	$1,115	----------	$638,225
New positions	----------	----------	----------	----------	----------	786	75	5,400	14	6	6	6,287
	----------	----------	----------	----------	----------	$6,288,000	$600,000	$39,258,000	$112,000	$48,000	$48,000	$46,354,000
Estimated end of year employment	683	3,220	1,440	2,736	416	2,000	300	5,500	46	26	6	16,373
	$5,936,774	$22,444,084	$10,518,547	$19,894,614	$2,936,752	$15,711,806	$1,925,284	$40,175,000	$419,605	$236,265	$48,000	$120,246,731
Deduct regular lapses	$29,274	$112,584	$52,547	$99,114	$14,352	$46,806	$6,634	$200,000	$1,605	$710	----------	$563,626
Deduct new position lapses	----------	----------	----------	----------	----------	1,572,000	150,000	----------	28,000	12,000	$12,000	1,774,000
Deduct within-grade lapses	37,500	57,500	30,000	47,500	7,400	40,000	2,650	95,000	1,000	555	----------	319,105
Add terminal leave	7,000	21,000	30,000	60,000	4,000	40,000	5,000	100,000	----------	----------	----------	267,000
Net lapse deduction	59,774	149,084	52,547	86,614	17,752	1,618,806	154,284	195,000	30,605	13,265	12,000	2,389,731
Net cost of positions	5,877,000	22,295,000	10,466,000	19,808,000	2,919,000	14,093,000	1,771,000	39,980,000	389,000	223,000	36,000	117,857,000
Intermittent employment	75,000	----------	----------	----------	----------	75,000	----------	100,000	----------	----------	----------	250,000
Regular pay for excess days	22,800	86,500	40,600	76,500	11,300	60,400	7,600	154,500	1,600	1,000	200	463,000
Overtime and holiday pay	125,000	181,000	78,000	138,000	139,500	1,300,000	120,300	7,000,000	2,400	2,000	800	9,087,000
Nightwork differential	----------	45,000	64,000	72,000	100	55,600	14,300	200,000	----------	----------	----------	451,000
Other allowances	200	1,500	1,400	6,500	100	50,000	1,800	5,500	----------	----------	----------	67,000
Reimbursable details	100,000	----------	----------	----------	50,000	200,000	----------	100,000	----------	----------	----------	450,000
All other personal services	323,000	314,000	184,000	293,000	201,000	1,741,000	144,000	7,560,000	4,000	3,000	1,000	10,768,000
Total personal services	6,200,000	22,609,000	10,650,000	20,101,000	3,120,000	15,834,000	1,915,000	47,540,000	393,000	226,000	37,000	128,625,000

02 Travel

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$370,940	$922,700	$1,100,000
Langley Center	238,457	403,800	460,000
Ames Center	99,485	110,000	160,000
Lewis Center	130,516	180,000	300,000
Flight Center	71,389	90,000	135,000
Goddard Center	170,496	1,053,500	2,210,000
Wallops Station	9,496	71,400	150,000
NASA Huntsville			1,281,000
Western office	3,219	20,000	25,000
AMRO office	1,356	15,000	18,000
PMRO office			10,000
Wright office	1,864		
Total, all locations	1,097,218	2,866,400	5,849,000
Analysis by types of travel:			
Direction and coordination of program activities at NASA installations	131,983	338,900	1,110,000
Coordination of program activities with other Government agencies and the scientific community	362,490	781,600	1,440,000
Travel of technicians to launching sites and global tracking stations	111,690	943,000	1,949,500
Management of business activities	125,745	206,200	383,600
Meetings of NASA technical committees and working panels	207,119	303,600	360,000
Meetings of technical and scientific societies	89,966	129,000	189,500
Travel to initial duty stations	30,214	86,000	250,300
Temporary assignments and transfers	13,836	19,300	32,500
Travel to emergency relocation site	1,180	2,000	2,000
Reimbursement for local transportation and toll charges	12,058	16,800	21,600
Travel of consultants and lecturers	7,078	40,000	110,000
Travel of congressional members and staffs	3,859		
Total, all types of travel	1,097,218	2,866,400	5,849,000

03 Transportation of things

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$49,588	$54,000	$14,000
Langley Center	111,456	8,000	12,000
Ames Center	35,934	10,000	15,000
Lewis Center	111,755	15,000	20,000
Flight Center	9,709	7,000	3,000
Goddard Center	41,255	80,000	236,000
Wallops Station	14,999	7,000	22,000
NASA Huntsville			100,000
Western office		5,000	10,000
AMRO office		5,000	5,000
PMRO office			5,000
Total, all locations	374,696	191,000	442,000
Analysis by types of transportation:			
Transportation of supplies and equipment	251,966	[1]	[1]
Drayage and other local transportation	18,739	[1]	[1]
Transportation of household goods and personal effects	103,991	191,000	442,000
Total, all types of transportation	374,696	191,000	442,000

[1] Funded under "Research and development."

04 Communication services

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$205,531	$432,000	$535,000
Langley Center	51,009	70,000	82,000
Ames Center	32,573	35,000	42,000
Lewis Center	71,039	75,000	94,000
Flight Center	62,313	15,000	20,000
Goddard Center	17,377	203,000	244,000
Wallops Station	5,842	33,600	40,000
NASA Huntsville			229,000
Western office	4,361	10,000	12,000
AMRO office	1,776	10,000	12,000
PMRO office			4,000
Wright office	48		
Total, all locations	451,869	883,600	1,314,000
Analysis by types of service:			
Local telephone and exchange service	125,225	195,770	249,000
Long-distance toll charges	149,181	430,130	627,000
Telegraph service	37,072	137,625	257,900
Postage	78	75	100
Penalty mail	80,000	120,000	180,000
Leased lines	60,313	(1)	(1)
Total, all types of communication services	451,869	883,600	1,314,000

[1] Funded under "Research and development."

05 Rents and utility services

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$16,559	$103,000	$30,000
Langley Center	2,709,143	2,971,000	4,407,000
Ames Center	2,651,526	2,828,000	3,565,000
Lewis Center	2,608,431	3,044,800	3,693,000
Flight Center	81,565	93,000	179,000
Goddard Center	3,774	338,000	5,463,000
Wallops Station	50,101	125,000	409,000
NASA Huntsville			6,050,000
Western Office	10,047	46,000	46,000
Total, all locations	8,131,146	9,548,800	23,842,000
Analysis by types of rents and services:			
Electric power:			
Langley Center	1,880,782	2,032,000	2,592,000
Ames Center	2,238,271	2,268,000	2,612,000
Lewis Center	2,014,946	2,073,800	2,405,000
Flight Center	7,152	8,000	14,000
Goddard Center		8,000	75,000
Wallops Station	50,075	105,000	145,000
NASA Huntsville			[1]
Total, electric power	6,191,226	6,494,800	7,843,000
Water:			
Ames Center	36,224	45,000	60,000
Lewis Center	42,276	51,000	60,000
Flight Center	204	250	250
Goddard Center		2,000	25,000
Total, water	78,704	98,250	145,250
Gas:			
Ames Center	36,698	44,000	64,000
Lewis Center	274,284	317,000	375,000
Flight Center	7,750	8,750	14,750
Total, gas	318,732	369,750	453,750
Miscellaneous utility services: Ames Center	931	1,000	1,000
Data-reduction equipment rental:			
NASA Headquarters	12,071		
Langley Center	825,188	936,000	1,812,000
Ames Center	338,753	469,000	826,000
Lewis Center	275,987	600,000	850,000
Flight Center	66,210	75,500	149,500
Goddard Center	3,774	328,000	5,363,000
Wallops Station		19,900	263,900
NASA Huntsville			6,050,000
Total, data-reduction equipment rental	1,521,983	2,428,400	15,314,400
Miscellaneous rentals:			
NASA Headquarters	4,488	103,000	30,000
Langley Center	3,173	3,000	3,000
Ames Center	649	1,000	2,000
Lewis Center	938	3,000	3,000
Flight Center	249	500	500
Wallops Station	26	100	100
Western Office	10,047	46,000	46,000
Total, miscellaneous rentals	19,570	156,600	84,600
Total, all rents and utility services	8,131,146	9,548,800	23,842,000

[1] Electric power and other utilities for NASA Huntsville will be provided by contract with the Department of the Army; funding included under object 07, Support of NASA Plant, in the "Research and development" appropriation.

Statement of utilities and other contract services to be provided by AOMC for NASA Huntsville facility

[Funded under Object "Support of NASA plant, Research and development"]

Utilities:	
Electricity	$18,000
Water	95,000
Heating	505,000
Other:	
Maintenance of roads, buildings, equipment rail system, sanitation, telephone lines, fire protection, and security	1,023,000
Printing and photographic services	115,000
Laundry and cleaning	142,000
Property disposal	80,000
Foundry, machine fabrication, etc.	125,000
Total	2,603,000

06 Printing and reproduction

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$121,492	$142,000	$180,000
Langley Center	18,103	25,000	26,000
Ames Center	14,221	7,000	15,000
Lewis Center	5,198	4,000	10,000
Flight Center	1,203	2,000	2,000
Goddard Center	249	20,000	25,000
Wallops Station		3,000	5,000
NASA Huntsville			100,000
Total, all locations	160,466	203,000	363,000
Analysis by types of printing:			
Administrative semiannual report	9,141	10,000	10,000
Technical reports	77,185	125,000	170,000
Annual volume of consolidated technical reports		14,000	18,000
Printed forms and letterheads	1,943	4,000	15,000
Miscellaneous printing, binding, and storage of type	72,197	50,000	150,000
Total, all types of printing	160,466	203,000	363,000

07 Other contractual services

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$1,555,818	$516,800	$1,306,000
Langley Center	701,930	66,850	255,000
Ames Center	325,324	31,000	116,000
Lewis Center	581,202	59,700	220,000
Flight Center	132,643	7,450	29,000
Goddard Center	6,804	26,000	147,000
Wallops Station	70,927	4,000	22,000
NASA Huntsville		1,000	438,000
Western Office	3,048	700	4,200
AMRO Office	50	500	2,500
PMRO Office			800
Wright Office	56		
Total, all locations	3,377,802	714,000	2,540,500
Analysis by types of services:			
Research contracts	816,510	(1)	(1)
Repairs and alterations	1,090,917	(1)	(1)
Miscellaneous contractual services	754,529	(1)	(1)
Federal life insurance	182,166	214,000	392,200
Federal health program [2]			900,300
Services by other Government agencies:			
Research services	148,367	(1)	(1)
Security investigations	178,595	500,000	1,248,000
Other services	206,718	(1)	(1)
Total, other contractual services	3,377,802	714,000	2,540,500

[1] Funded under "Research and development."

[2] Pursuant to the Federal Employees Health Benefits Act of 1959 (Public Law 86-382) Government contributions toward the cost of Federal employees hospitalization insurance were computed in accordance with Bureau of the Budget instructions as follows:

Estimated man-years, fiscal year 1961	16,100
Estimated participation (90 percent of estimated man-years)	14,490
Classes of enrollment:	
Family type insurance (60 percent of estimated participation)	8,694
Individual type insurance (40 percent of estimated participation)	5,796
Cost computations:	
Family (8,694 times $3.12 biweekly contributions)	$705,000
Individual (5,796 times $1.30 biweekly contributions)	195,300
	900,300

08 Supplies and materials

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$191,115		
Langley Center	2,385,304		
Ames Center	1,177,031		
Lewis Center	1,994,105		
Flight Center	297,161		
Wallops Station	467,789		
Western Office	1,352		
AMRO Office	125		
Wright Office	10		
Total, all locations	6,513,992	(1)	(1)

[1] Funded under "Research and development."

09 Equipment

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$311,855		
Langley Center	707,611		
Ames Center	1,024,215		
Lewis Center	1,019,887		
Flight Center	185,820		
Goddard Center	94,413		
Wallops Station	41,080		
Western Office	17,526		
Total, all locations	3,402,407	(1)	(1)

[1] Funded under "Research and development."

11 Grants, subsidies, and contributions

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$152,505	$321,400	$380,000
Langley Center	1,420,251	1,416,150	1,441,000
Ames Center	644,968	665,850	677,000
Lewis Center	1,236,204	1,271,200	1,280,000
Flight Center	129,084	163,200	188,000
Goddard Center	91,719	607,520	911,000
Wallops Station	40,068	81,000	114,000
NASA Huntsville		14,000	2,585,000
Western Office	3,122	15,480	25,300
AMRO Office	954	10,500	14,500
PMRO Office			2,700
Wright Office	933		
Total, all locations	3,719,808	4,566,300	7,618,500

CALCULATION OF GOVERNMENT CONTRIBUTIONS TO RETIREMENT FUND

Total, all personal services		$125,425,000
Personal services not subject to retirement deductions:		
Intermittent employment	$250,000	
Overtime and holiday pay	5,887,000	
Nightwork differential applicable to classified employees	100,000	
Other allowances	67,000	
Reimbursements for details from other Government agencies	450,000	
Terminal leave payments	267,000	
Salaries subject to deductions for social security	1,196,000	
		−8,217,000
Total, personal services subject to retirement deductions		117,208,000
Total, Government contributions computed at 6½ percent		7,618,500

13 Refunds, awards, and indemnities

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$1,506	$129,000	$140,000
Langley Center	555	1,000	1,000
Ames Center	711	1,000	1,000
Lewis Center	885	1,000	1,000
Flight center		1,000	1,000
Goddard Center		1,000	2,000
NASA Huntsville			1,000
Total, all locations	3,202	134,000	147,000
Analysis by types of awards and claims:			
Incentive awards	1,721	5,000	7,000
Tort claims	1,481	129,000	140,000
Total, all awards and claims	3,202	134,000	147,000

Analysis of incentive awards and tort claims

INCENTIVE AWARDS

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Analysis by location:			
Headquarters	$25		$1,000
Langley	55	$1,000	1,000
Ames	711	1,000	1,000
Lewis	845	1,000	1,000
FRC	85	1,000	1,000
Goddard		1,000	1,000
Huntsville			1,000
Total	1,721	5,000	7,000

TORT CLAIMS

Analysis by location:			
Headquarters		$106,000	
Langley	$412	21,000	
Lewis	1,069	2,000	
Total	1,481	129,000	$140,000
Analysis by types of tort claims:			
Patent infringement		105,000	
Automobile accidents	1,327	4,500	
Crop damage (spraying)		500	
Personal injuries		19,000	
Sonic test damages	154		
Total	1,481	129,000	140,000

15 Taxes and assessments

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$967	$1,000	$1,000
Langley Center	1,106	1,500	2,000
Ames Center	3,434	3,000	3,000
Lewis Center	1,657	2,000	2,000
Flight Center	1,438	2,000	2,000
Goddard Center	1,968	2,000	4,000
Wallops Station		500	1,000
NASA Huntsville			4,000
Western Office		100	
Total, all locations	10,570	12,100	19,000
Analysis by types of taxes and assessments: Social security taxes (CICA)	10,570	12,100	19,000

Estimates of appropriations, "Salaries and expenses," fiscal year 1961

		Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01	Personal services:			
	Number of permanent positions (end of year)	9,286	10,086	16,373
	Annual cost of permanent positions (end of year)	$65,142,007	$73,254,506	$120,246,731
	Deduct lapses	6,294,304	3,328,066	2,389,731
	Net cost of permanent positions	[1] 58,847,703	69,926,440	117,857,000
	Intermittent employment	[1] 4,016	67,900	250,000
	Regular pay above 52-week base	[1] 246,121	558,710	463,000
	Overtime and nightwork differential	[1] 776,388	1,530,300	9,538,000
	Other allowances	[2] 15,574	33,000	67,000
	Reimbursable details	27,311	164,450	450,000
	Total, personal services	[1] 59,917,113	72,280,800	128,625,000
02	Travel	[1] 1,285,911	2,866,400	5,849,000
03	Transportation of things:			
	Household goods	[1] 103,991	191,000	442,000
	All other	[1] 279,887	[2] 1,485,000	[2] 3,993,000
04	Communication services:			
	Leased lines	60,313	[2] 156,500	[2] 336,000
	All other	391,556	883,600	1,314,000
05	Rents and utility services:			
	Electric power	6,191,226	6,494,800	7,843,000
	Other utilities	398,367	469,000	600,000
	Rentals	1,541,553	2,585,000	15,399,000
06	Printing and reproduction	160,466	203,000	363,000
07	Other contractual services:			
	Research contracts	816,510		
	Repairs and alterations	[1] 1,221,710	[2] 2,012,100	[2] 5,060,000
	Miscellaneous services	[1] 947,020	[2] 1,522,400	[2] 7,403,000
	Services by other Government agencies	[1] 20,421,095	[2] 2,556,000	[2] 5,079,000
	Security investigations	178,595	500,000	1,248,000
	Federal life insurance	[1] 185,440	214,000	392,200
	Federal health program			900,300
08	Supplies and materials	[1] 6,927,053	[2] 8,636,000	[2] 17,607,000
09	Equipment	[1] 3,632,845	[2] 6,316,000	[2] 11,867,000
11	Grants, subsidies, and contributions	[1] 3,785,722	4,566,300	7,618,500
13	Refunds, awards, and indemnities	3,202	134,000	147,000
15	Taxes and assessments	[1] 10,868	12,100	19,000
	Total	108,460,443	114,084,000	222,105,000
	Partially or fully funded under "Research and development"	−22,472,147	−22,684,000	−51,345,000
	Unobligated balance	298,004		
	Total allotment	86,286,300	91,400,000	70,760,000

[1] Partially funded.
[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

NASA HEADQUARTERS

		Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01	Personal services:			
	Number of permanent positions (end of year)	428	683	683
	Annual cost of permanent positions (end of year)	$3,678,369	$5,861,774	$5,936,774
	Deduct lapses	1,291,973	1,178,674	59,774
	Net cost of permanent positions	2,386,396	4,683,100	5,877,000
	Intermittent employment	1,029	50,000	75,000
	Regular pay above 52-week base	14,165	45,400	22,800
	Overtime and nightwork differential	42,405	108,600	125,000
	Other allowances	127	300	200
	Reimbursable details	27,311	40,000	100,000
	Total personal services	2,471,433	4,927,400	6,200,000
02	Travel	370,940	922,700	1,100,000
03	Transportation of things:			
	Household goods	13,798	54,000	14,000
	All other	35,790	[2] 200,000	[2] 300,000
04	Communication services:			
	Leased lines	4,524	[2] 34,000	[2] 40,000
	All other	201,007	432,000	535,000
05	Rents and utility services:			
	Electric power			
	Other utilities			
	Rentals	16,559	103,000	30,000
06	Printing and reproduction	121,492	142,000	180,000
07	Other contractual services:			
	Research contracts	816,510		
	Repairs and alterations	6,282	[2] 10,000	[2] 10,000
	Miscellaneous services	[1] 307,650	[2] 469,000	[2] 570,000
	Services by other Government agencies	[1] 271,314	[2] 580,000	[2] 620,000
	Security investigations	178,595	500,000	1,248,000
	Federal life insurance	7,467	16,800	20,000
	Federal health program			38,000
08	Supplies and materials	[1] 211,776	[2] 240,000	[2] 320,000
09	Equipment	[1] 349,241	[2] 150,000	[2] 165,000
11	Grants, subsidies, and contributions	152,505	321,400	384,000
13	Refunds, awards, and indemnities	1,506	129,000	140,000
15	Taxes and assessments	967	1,000	1,000
	Total	5,539,356	9,232,300	11,918,000
	Partially or fully funded under "Research and development"	−90,047	−1,683,000	−2,025,000
	Unobligated balance	89,551		
	Total allotment	5,538,860	7,549,300	9,890,000

[1] Partially funded.
[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

LANGLEY RESEARCH CENTER

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01 Personal services:			
Number of permanent positions (end of year)	3,297	3,220	3,220
Annual cost of permanent positions (end of year)	$22,209,951	$22,329,084	$22,444,084
Deduct lapses	308,964	211,984	149,084
Net cost of permanent positions	21,900,987	22,117,100	22,295,000
Intermittent employment			
Regular pay above 52-week base	84,099	168,000	86,500
Overtime and nightwork differential	197,791	196,000	226,000
Other allowances	520	1,100	1,500
Reimbursable details			
Total personal services	22,183,397	22,482,200	22,609,000
02 Travel	238,457	403,800	460,000
03 Transportation of things:			
Household goods	29,534	8,000	12,000
All other	81,922	[2] 117,400	[2] 120,000
04 Communication services:			
Leased lines		[2] 8,500	[2] 10,000
All other	51,009	70,000	82,000
05 Rents and utility services:			
Electric power	1,880,782	2,032,000	2,592,000
Other utilities			
Rentals	828,361	939,000	1,815,000
06 Printing and reproduction	18,103	25,000	26,000
07 Other contractual services:			
Research contracts			
Repairs and alterations	[1] 597,659	[2] 565,200	[2] 958,000
Miscellaneous services	[1] 230,136	[2] 228,000	[2] 246,000
Services by other Government agencies	82,997	[2] 82,000	[2] 138,000
Security investigations			
Federal life insurance	72,342	66,850	74,000
Federal health program			181,000
08 Supplies and materials	[1] 2,562,086	[2] 3,224,500	[2] 5,610,000
09 Equipment	[1] 768,028	[2] 1,037,000	[2] 2,018,000
11 Grants, subsidies, and contributions	1,420,251	1,416,150	1,441,000
13 Refunds, awards, and indemnities	55	1,000	1,000
15 Taxes and assessments	1,106	1,500	2,000
Total	31,046,225	32,708,100	38,395,000
Partially or fully funded under "Research and development"	−518,403	−5,262,600	−9,100,000
Unobligated balance	41,148		
Total allotment	30,568,970	27,445,500	29,295,000

[1] Partially funded.
[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

AMES RESEARCH CENTER

		Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01	Personal services:			
	Number of permanent positions (end of year)	1,478	1,440	1,440
	Annual cost of permanent positions (end of year)	$10,374,891	$10,458,547	$10,518,567
	Deduct lapses	265,178	68,697	52,567
	Net cost of permanent positions	10,109,713	10,389,850	10,466,000
	Intermittent employment			
	Regular pay above 52-week base	39,186	78,900	40,000
	Overtime and nightwork differential	86,393	80,000	142,000
	Other allowances	1,151	1,000	1,400
	Reimbursable details		16,450	
	Total personal services	10,236,443	10,566,200	10,650,000
02	Travel	99,485	110,000	160,000
03	Transportation of things:			
	Household goods	9,005	10,000	15,000
	All other	26,929	[2] 40,000	[2] 35,000
04	Communication services:			
	Leased lines			
	All other	32,573	35,000	42,000
05	Rents and utility services:			
	Electric power	2,238,271	2,268,000	2,612,000
	Other utilities	73,853	90,000	125,000
	Rentals	339,402	470,000	838,000
06	Printing and reproduction	14,221	7,000	15,000
07	Other contractual services:			
	Research contracts			
	Repairs and alterations	160,832	[2] 508,500	[2] 766,000
	Miscellaneous services	124,306	[2] 240,500	[2] 252,000
	Services by other Government agencies	8,165	[2] 18,000	[2] 107,000
	Security investigations			
	Federal life insurance	32,021	31,000	35,000
	Federal health program			81,000
08	Supplies and materials	1,177,031	[2] 1,500,000	[2] 1,500,000
09	Equipment	1,024,215	[2] 1,330,000	[2] 1,400,000
11	Grants, subsidies, and contributions	644,968	665,850	677,000
13	Refunds, awards, and indemnities	711	1,000	1,000
15	Taxes and assessments	3,434	3,000	3,000
	Total	16,245,865	17,894,050	19,314,000
	Partially or fully funded under "Research and development"		−3,637,000	−4,070,000
	Unobligated balance	53,170		
	Total allotment	16,299,035	14,257,050	15,244,000

[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

LEWIS RESEARCH CENTER

		Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01	Personal services:			
	Number of permanent positions (end of year)	2,783	2,736	2,736
	Annual cost of permanent positions (end of year)	$19,606,568	$19,799,614	$19,894,614
	Deduct lapses	434,278	+76,076	86,614
	Net cost of permanent positions	19,172,290	19,875,690	19,808,000
	Intermittent employment			
	Regular pay above 52-week base	74,555	152,310	76,500
	Overtime and nightwork differential	155,409	153,500	210,000
	Other allowances	5,890	6,000	6,500
	Reimbursable details			
	Total personal services	19,408,144	20,187,500	20,101,000
02	Travel	130,516	180,000	300,000
03	Transportation of things:			
	Household goods	16,959	15,000	20,000
	All other	94,796	[2] 173,000	[2] 300,000
04	Communication services:			
	Leased lines	574	[2] 3,000	[2] 6,000
	All other	70,465	75,000	94,000
05	Rents and utility services:			
	Electric power	2,014,946	2,073,800	2,405,000
	Other utilities	316,560	368,000	435,000
	Rentals	276,925	603,000	853,000
06	Printing and reproduction	5,198	4,000	10,000
07	Other contractual services:			
	Research contracts	300,759	[2] 528,000	[2] 669,000
	Repairs and alterations	219,735	[2] 467,000	[2] 700,000
	Miscellaneous services	3,336	[2] 5,000	[2] 5,000
	Services by other Government agencies			
	Security investigations	57,372	59,700	66,000
	Federal life insurance			154,000
	Federal health program			
08	Supplies and materials	[1] 2,181,761	[2] 2,800,000	[2] 4,000,000
09	Equipment	1,019,887	[2] 2,280,000	[2] 3,500,000
11	Grants, subsidies, and contributions	1,236,204	1,271,200	1,283,000
13	Refunds, awards, and indemnities	845	1,000	1,000
15	Taxes and assessments	1,657	2,000	2,000
	Total	27,356,639	31,096,200	34,904,000
	Partially or fully funded under "Research and development"	−187,656	−6,256,000	−9,180,000
	Unobligated balance	46,244		
	Total allotment	27,215,227	24,840,200	25,724,000

[1] Partially funded.
[2] Fully funded.

***Estimates of appropriations, "Salaries and expenses" fiscal year 1961*—Continued**

FLIGHT RESEARCH CENTER

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01 Personal services:			
Number of permanent positions (end of year)	336	416	416
Annual cost of permanent positions (end of year)	$2,316,670	$2,921,952	$2,936,752
Deduct lapses	228,443	439,952	17,752
Net cost of permanent positions	2,088,227	2,482,000	2,919,000
Intermittent employment			
Regular pay above 52-week base	8,784	22,400	11,300
Overtime and nightwork differential	64,638	125,000	139,600
Other allowances	92	100	100
Reimbursable details		28,000	50,000
Total personal services	2,161,741	2,657,500	3,120,000
02 Travel	71,389	90,000	135,000
03 Transportation of things:			
Household goods	903	7,000	3,000
All other	8,806	[2] 16,600	[2] 9,000
04 Communication services:			
Leased lines	52,036	[2] 108,000	[2] 108,000
All other	10,277	15,000	20,000
05 Rents and utility services:			
Electric power	7,152	8,000	14,000
Other utilities	7,954	9,000	15,000
Rentals	66,459	76,000	150,000
06 Printing and reproduction	1,203	2,000	2,000
07 Other contractual services:			
Research contracts			
Repairs and alterations	94,493	[2] 92,500	[2] 60,000
Miscellaneous services	[1] 33,036	[2] 40,000	[2] 85,000
Services by other Government agencies	861	[2] 2,500	[2] 4,000
Security investigations			
Federal life insurance	6,138	7,450	10,000
Federal health program			19,000
08 Supplies and materials	[1] 299,866	[2] 250,000	[2] 400,000
09 Equipment	[1] 202,792	[2] 324,000	[2] 384,000
11 Grants, subsidies, and contributions	129,084	163,200	188,000
13 Refunds, awards, and indemnities	85	1,000	1,000
15 Taxes and assessments	1,438	2,000	2,000
Total	3,155,713	3,871,750	4,729,000
Partially or fully funded under "Research and development"	−21,562	−833,600	−1,050,000
Unobligated balance	20,057		
Total allotment	3,154,208	3,038,150	3,679,000

[1] Partially funded.
[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

GODDARD SPACE FLIGHT CENTER

		Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01	Personal services:			
	Number of permanent positions (end of year)	782	1,214	2,000
	Annual cost of permanent positions (end of year)	$5,852,969	$9,343,806	$15,711,806
	Deduct lapses	3,351,540	851,356	1,618,806
	Net cost of permanent positions	[1] 2,501,429	8,492,450	14,093,000
	Intermittent employment	[1] 2,987	17,900	75,000
	Regular pay above 52-week base	[1] 21,095	71,900	60,400
	Overtime and nightwork differential	[1] 201,519	786,000	1,355,600
	Other allowances	[2] 7,794	23,000	50,000
	Reimbursable details		80,000	200,000
	Total personal services	[1] 2,734,824	9,471,250	15,834,000
02	Travel	359,189	1,053,500	2,210,000
03	Transportation of things:			
	Household goods	[1] 33,792	80,000	236,000
	All other	[1] 16,645	[2] 916,000	[2] 1,012,000
04	Communication services:			
	Leased lines	3,179		
	All other	14,198	203,000	244,000
05	Rents and utility services:			
	Electric power		8,000	75,000
	Other utilities		2,000	25,000
	Rentals	3,774	328,000	5,363,000
06	Printing and reproduction	249	20,000	25,000
07	Other contractual services:			
	Research contracts			
	Repairs and alterations	[2] 1,651	[2] 107,800	[2] 600,000
	Miscellaneous services	[1] 20,876	[2] 50,000	[2] 131,000
	Services by other Government agencies	[2] 20,054,010	[2] 1,807,000	[2] 1,600,000
	Security investigations			
	Federal life insurance	[1] 7,746	26,000	46,000
	Federal health program			101,000
08	Supplies and materials	[2] 25,257	[2] 210,000	[2] 1,227,000
09	Equipment	210,076	[2] 1,100,000	[2] 1,498,000
11	Grants, subsidies, and contributions	[1] 157,633	607,520	919,000
13	Refunds, awards, and indemnities		1,000	2,000
15	Taxes and assessments	[1] 2,266	2,000	4,000
	Total	23,645,365	15,993,070	31,152,000
	Partially or fully funded under "Research and development"	−21,654,479	−4,190,800	−6,068,000
	Unobligated balance	30,214		
	Total allotment	2,021,100	11,802,270	25,084,000

[1] Partially funded.
[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

WALLOPS STATION

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01 Personal services:			
Number of permanent positions (end of year)	171	225	300
Annual cost of permanent positions (end of year)	$986,974	$1,319,974	$1,925,284
Deduct lapses	374,787	31,874	154,284
Net cost of permanent positions	612,187	1,288,100	1,771,000
Intermittent employment			
Regular pay above 52-week base	3,793	10,400	7,600
Overtime and nightwork differential	28,233	74,600	134,600
Other allowances		1,500	1,800
Reimbursable details			
Total personal services	644,213	1,374,600	1,915,000
02 Travel	9,496	71,400	150,000
03 Transportation of things:			
Household goods		7,000	22,000
All other	14,999	[2] 20,000	[2] 80,000
04 Communication services:			
Leased lines		[2] 3,000	[2] 72,000
All other	5,842	33,600	40,000
05 Rents and utility services:			
Electric power	50,075	105,000	145,000
Other utilities			
Rentals	26	20,000	264,000
06 Printing and reproduction		3,000	5,000
07 Other contractual services:			
Research contracts			
Repairs and alterations	58,878	[2] 189,500	[2] 191,000
Miscellaneous services	9,535	[2] 20,000	[2] 42,000
Services by other Government agencies	412	[2] 61,500	[2] 2,000
Security investigations			
Federal life insurance	2,102	4,000	6,000
Federal health program			16,000
08 Supplies and materials	467,789	[2] 405,000	[2] 540,000
09 Equipment	41,080	[2] 70,000	[2] 125,000
11 Grants, subsidies, and contributions	40,068	81,000	114,000
13 Refunds, awards, and indemnities			
15 Taxes and assessments		500	1,000
Total	1,344,515	2,469,100	3,730,000
Partially or fully funded under "Research and development"		−769,000	−1,052,000
Unobligated balance	12,305		
Total allotment	1,356,820	1,700,100	2,678,000

[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

NASA HUNTSVILLE FACILITY

		Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01	Personal services:			
	Number of permanent positions (end of year)		100	5, 500
	Annual cost of permanent positions (end of year)		$727, 000	$40, 175, 000
	Deduct lapses		525, 000	195, 000
	Net cost of permanent positions		202, 000	39, 980, 000
	Intermittent employment			100, 000
	Regular pay above 52-week base		5, 600	154, 500
	Overtime and nightwork differential		4, 400	7, 200, 000
	Other allowances			5, 500
	Reimbursable details			100, 000
	Total personal services		212, 000	47, 540, 000
02	Travel			1, 281, 000
03	Transportation of things:			
	Household goods			100, 000
	All other			[2] 2, 124, 000
04	Communication services:			
	Leased lines			[2] 100, 000
	All other			229, 000
05	Rents and utility services:			
	Electric power			
	Other utilities			
	Rentals			6, 050, 000
06	Printing and reproduction			
07	Other contractual services:			
	Research contracts			100, 000
	Repairs and alterations			[2] 1, 800, 000
	Miscellaneous services			[2] 5, 370, 000
	Services by other Government agencies			[2] 2, 603, 000
	Security investigations			
	Federal life insurance		1, 000	132, 000
	Federal health program			306, 000
08	Supplies and materials			[2] 4, 000, 000
09	Equipment			[2] 2, 755, 000
11	Grants, subsidies, and contributions		14, 000	2, 570, 000
13	Refunds, awards, and indemnities			1, 000
15	Taxes and assessments			4, 000
	Total		227, 000	77, 065, 000
	Partially or fully funded under "Research and development"			−18, 752, 000
	Unobligated balance			
	Total allotment		227, 000	58, 313, 000

[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

WESTERN OPERATIONS OFFICE

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01 Personal services:			
Number of permanent positions (end of year)	7	32	46
Annual cost of permanent positions (end of year)	$64,455	$305,605	$419,605
Deduct lapses	16,820	67,255	30,605
Net cost of permanent positions	47,635	238,350	389,000
Intermittent employment			
Regular pay above 52-week base	247	2,300	1,600
Overtime and nightwork differential		1,000	2,400
Other allowances			
Reimbursable details			
Total personal services	47,882	241,650	393,000
02 Travel	3,219	20,000	25,000
03 Transportation of things:			
Household goods		5,000	10,000
All other		[2] 1,000	[2] 1,000
04 Communication services:			
Leased lines			
All other	4,361	10,000	12,000
05 Rents and utility services:			
Electric power			
Other utilities			
Rentals	10,047	46,000	46,000
06 Printing and reproduction			
07 Other contractual services:			
Research contracts			
Repairs and alterations	1,148	[2] 10,600	[2] 6,000
Miscellaneous services	1,746	[2] 7,900	[2] 7,000
Services by other Government agencies			
Security investigations			
Federal life insurance	154	700	1,700
Federal health program			2,500
08 Supplies and materials	1,352	[2] 4,500	[2] 6,000
09 Equipment	17,526	[2] 22,000	[2] 15,000
11 Grants, subsidies, and contributions	3,122	15,480	25,300
13 Refunds, awards, and indemnities			
15 Taxes and assessments		100	
Total	90,557	384,930	550,500
Partially or fully funded under "Research and development"		−46,000	−35,000
Unobligated balance	4,258		
Total allotment	94,815	338,930	515,500

[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

ATLANTIC MISSILE RANGE OPERATIONS OFFICE

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01 Personal services:			
Number of permanent positions (end of year)	4	20	26
Annual cost of permanent positions (end of year)	$51,160	$187,150	$236,265
Deduct lapses	36,675	29,350	13,265
Net cost of permanent positions	14,485	157,800	223,000
Intermittent employment			
Regular pay above 52-week base	197	1,500	1,000
Overtime and nightwork differential		1,200	2,000
Other allowances			
Reimbursable details			
Total personal services	14,682	160,500	226,000
02 Travel	1,356	15,000	18,000
03 Transportation of things:			
Household goods		5,000	5,000
All other		[2] 1,000	[2] 1,000
04 Communication services:			
Leased lines			
All other	1,776	10,000	12,000
05 Rents and utility services:			
Electric power			
Other utilities			
Rentals			
06 Printing and reproduction			
07 Other contractual services:			
Research contracts			
Repairs and alterations			
Miscellaneous services			
Services by other Government agencies			
Security investigations			
Federal life insurance	50	500	1,000
Federal health program			1,500
08 Supplies and materials	125	[2] 2,000	[2] 3,000
09 Equipment		[2] 3,000	[2] 4,000
11 Grants, subsidies, and contributions	954	10,500	14,500
13 Refunds, awards, and indemnities			
15 Taxes and assessments			
Total	18,943	207,500	286,000
Partially or fully funded under "Research and development"		−6,000	−8,000
Unobligated balance	1,057		
Total allotment	20,000	201,500	278,000

[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

PACIFIC MISSILE RANGE OPERATIONS OFFICE

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01 Personal services:			
Number of permanent positions (end of year)			6
Annual cost of permanent positions (end of year)			$48,000
Deduct lapses			12,000
Net cost of permanent positions			36,000
Intermittent employment			
Regular pay above 52-week base			
Overtime and nightwork differential			200
Other allowances			800
Reimbursable details			
Total personal services			37,000
02 Travel			10,000
03 Transportation of things:			
Household goods			5,000
All other			[2] 1,000
04 Communication services:			
Leased lines			
All other			4,000
05 Rents and utility services:			
Electric power			
Other utilities			
Rentals			
06 Printing and reproduction			
07 Other contractual services:			
Research contracts			
Repairs and alterations			
Miscellaneous services			
Services by other Government agencies			
Security investigations			
Federal life insurance			500
Federal health program			300
08 Supplies and materials			[2] 1,000
09 Equipment			[2] 3,000
11 Grants, subsidies, and contributions			2,700
13 Refunds, awards, and indemnities			
15 Taxes and assessments			
Total			64,500
Partially or fully funded under "Research and development"			−5,000
Unobligated balance			
Total allotment			59,500

[2] Fully funded.

Estimates of appropriations, "Salaries and expenses" fiscal year 1961—Continued

WRIGHT-PATTERSON LIAISON OFFICE

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01 Personal services:			
Number of permanent positions (end of year)			
Annual cost of permanent positions (end of year)			
Deduct lapses	+$14,354		
Net cost of permanent positions	14,354		
Intermittent employment			
Regular pay above 52-week base			
Overtime and nightwork differential			
Other allowances			
Reimbursable details			
Total personal services	14,354		
02 Travel	1,864		
03 Transportation of things:			
Household goods			
All other			
04 Communication services:			
Leased lines			
All other	48		
05 Rents and utility services:			
Electric power			
Other utilities			
Rentals			
06 Printing and reproduction			
07 Other contractual services:			
Research contracts			
Repairs and alterations	8		
Miscellaneous services			
Services by other Government agencies			
Security investigations			
Federal life insurance	48		
Federal health program			
08 Supplies and materials	10		
09 Equipment			
11 Grants, subsidies, and contributions	933		
13 Refunds, awards, and indemnities			
15 Taxes and assessments			
Total	17,265		
Partially or fully funded under "Research and development"			
Total allotment	17,265		

Support of NASA plant

	Fiscal year 1959			Fiscal year 1960, research and development	Fiscal year 1961, research and development
	Salaries and expenses	Research and development	Total		
Analysis by location:					
NASA Headquarters	$1,096,530	$90,047	$1,186,577	$1,683,000	$2,025,000
Langley Center	3,804,425	518,403	4,322,828	5,262,600	9,100,000
Ames Center	2,521,478		2,521,478	3,637,000	4,070,000
Lewis Center	3,633,192	187,656	3,820,848	6,256,000	9,180,000
Flight Center	670,328	21,562	691,890	833,600	1,050,000
Goddard Center	107,737	144,700	252,437	4,190,800	6,068,000
Wallops Station	592,693		592,693	769,000	1,052,000
NASA Huntsville					18,752,000
Western Office	21,772		21,772	46,000	35,000
AMRO Office	125		125	6,000	8,000
PMRO Office					5,000
Wright Office	18		18		
Total obligations, 1959	12,448,298	962,368	13,410,666		
New obligational authority, 1960 and 1961				22,684,000	51,345,000
1959 balance available for obligation in 1960		135,283	135,283		
Total	12,448,298	1,097,651	13,545,949	22,684,000	51,345,000
Analysis by object of expenditure:					
03 Transportation of things	271,055		271,055	1,485,000	3,993,000
04 Communication services	60,313		60,313	156,500	336,000
07 Other contractual services	2,200,531	318,869	2,519,400	6,090,500	17,542,000
08 Supplies and materials	6,513,992	413,061	6,927,053	8,636,000	17,607,000
09 Equipment	3,402,407	230,438	3,632,845	6,316,000	11,867,000
Total	12,448,298	962,368	13,410,666	22,684,000	51,345,000

Mr. KING. I have a few more questions I would like to ask.

Last year, as I remember, there were one or two items, one in particular, that caused this committee to raise a question or two. I think there was a piece of property, wasn't there, that had not yet been acquired?

Mr. BERESFORD. For the Jet Propulsion Laboratory in California. Is that the one you mean?

Mr. KING. I believe that was it. In any event, a question was raised on that and this committee did reject that particular item although I believe it was added in later by the Senate, as I recall, and was kept in at the conference committee.

But I am asking now: To your knowledge, are there any items here, at all, that might possibly raise a question which we should consider at this time, items which undoubtedly you feel are appropriate here and are prepared to defend, but nevertheless, items which someone not familiar with the facts might raise a question?

So I am asking you now whether there are such items, and if there are, if you could call them to our attention so that we could get into the record now your factual justification for including them here?

(Discussion off the record.)

Mr. ULMER. If I could try to answer your question this way, Mr. King: You raised the question of land procurement. This, as you know, is not an item that is in the salaries and expenses appropriation, but I would like to speak to it since you did raise it.

There is one small item of land procurement in the 1961 budget, I believe it is 3.5 acres of additional land at the Jet Propulsion Lab-

oratory. This is the only land acquisition in the entire budget. It is a small land area contiguous to the existing site and is required for some of the facilities being proposed under the construction and equipment section of the budget.

Mr. KING. That item then is not before this subcommittee?

Mr. ULMER. No, sir.

Mr. KING. That will be dealt with by the other subcommittee?

Mr. ULMER. Correct. It is under the construction and equipment budget.

If I may give just a general answer to your question: The major item of increase in the salaries and expenses appropriation involves the takeover by NASA of the Huntsville facility. In any of these breakdowns that you examine in detail, you will find that the major items of increase come about as a result of this action. This is true in travel, transportation, in rents and utilities, in the retirement fund, in the personal services fund. I think that most of the questions that you may get on the detailed sheets can be brought back again to the fact that we are funding on a full year basis for the first time in 1961 the entire staff of 5,500 people for the Huntsville facility.

That involves a total salaries and expenses budget of over $55 million, and this by far, takes up the majority of the increase being requested for salaries and expenses for the entire agency.

Mr. KING. Last year the figure was what?

Mr. ULMER. It was zero.

Mr. KING. I mean——

Mr. ULMER. Total salaries and expenses?

Mr. KING. The total figure for salaries and expenses?

Mr. ULMER. 91.4 million.

Mr. KING. This is about an 85-percent increase, then?

Mr. ULMER. Yes, sir.

Mr. KING. And you are saying that the great bulk of that increase is represented by the Huntsville operation?

Mr. ULMER. Correct.

Mr. KING. The items that are not represented by the Huntsville operation, that is the other items of increase, would represent simply the normal expansion of operations that we had last year and you have merely—you are taking on added personnel, is that right?

Mr. ULMER. In 1961 we are taking on added personnel at the Goddard Center of approximately 800. That makes up a substantial amount of the additional increase being requested under personal services. There are also included in 1961 the full year costs of the personnel that were added during the current fiscal year, which we are funding in 1960 only on a partial-year basis as they come on board.

There is additional rental for computing equipment at all of our installations. This is a normal occurrence in this business. This is an economical method of meeting an increasing workload; the types of work that we are doing are requiring more and more calculations, more data points are being taken in our research experiments, and all installations, you will find, are asking for additional funds for the rental of computing equipment.

The contributions to the retirement fund, of course, increase proportionately to the personal services. But those are the major items in which we are requesting increases.

Mr. KING. The total NASA budget last year, as I recall, was $500 million, am I correct?

Mr. ULMER. It is $523 million, sir, including——

Mr. KING. Does that include the supplemental?

Mr. ULMER. It includes the supplemental.

Mr. KING. I believe the figure that was before us was $500 million as I recall, roughly, before the supplemental, is that correct?

Mr. ULMER. That is right, sir.

Mr. KING. And the total figure now before us is what?

Mr. ULMER. The total figure for 1961 is $915 million.

Mr. KING. $915 million?

Mr. ULMER. It is made up of the $802 million in the original President's budget submission, plus the $113 million amendment which was transmitted on February 8 by the President.

Mr. KING. That was to cover the Saturn project, was it not?

Mr. ULMER. For the most part, yes, sir.

Mr. KING. So there is an increase of considerably better than 100 percent.

Now, does the increase in salaries and expenses this year over last year maintain about the same proportion as the total increase of this year over last year?

Mr. ULMER. No, sir it does not. Mr. Horner's chart yesterday touched briefly on that in which he indicated a larger percentage of the 1961 budget being required for outside contracts. The S. & E. budget goes from $91.4 to $170 million. If you remove the Huntsville budget of approximately $58 million, we are talking about an increase here of 91 to 112, which is about a 23 percent increase, compared to the approximately 50 percent you mentioned. The major reason being, of course, that the increase in dollars in the budget is primarily in the areas where we will do outside contracting, not in an expansion of our in-house capability.

Mr. KING. All of these figures we are discussing are in-house capabilities?

Mr. ULMER. All of these that we are discussing are in-house.

Mr. KING. Where you let work out on contract, none of the salaries there would be included in this figure?

Mr. ULMER. Your statement is correct.

Mr. KING. They would come under R. & D.?

Mr. ULMER. R. & D., yes, sir.

Mr. KING. We were discussing any possible items that might be questioned and you mentioned that there was one item of acquisition of property but not before this subcommittee.

Mr. ULMER. Yes, sir.

Mr. KING. Are there any items at all, then, that are before this subcommittee that might cause someone to raise a legitimate question and legitimately want further explanation and further light?

(Discussion off the record.)

Mr. FULTON. Let me ask you specifically what you have done by way of rental of property, utilities, or expenses in connection with property in the District of Columbia, in Washington, D.C.

Mr. HJORNEVIK. In the District of Columbia, of course, Government agencies are required by law to lease properly only through the

General Services Administration, who is the lessor, and who is the assignor of all properties within the District of Columbia.

In order to make this work, the Budget Bureau has worked out an arrangement whereby when a need for space comes up during a fiscal year and General Services Administration has been unable to budget for it in advance, that some agencies have authority, as we do, to reimburse General Services Administration for the cost of the lease, but we still must go through General Services Administration to obtain leased property within the District of Columbia.

We are now negotiating with General Services Administration to lease us additional office space in the District of Columbia.

Mr. FULTON. How much do you need, and put a statement in the record at this point concerning what you have done in the past year and what you have estimated for the future.

Mr. HJORNEVIK. Yes, sir, we will be happy to do that.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—HEADQUARTERS OFFICE SPACE

The National Aeronautics and Space Administration has met all requirements for additional NASA Headquarters office space during the past year by occupying Government-owned space. For the past 3 months, however, we have been negotiating with the General Services Administration to obtain an additional 50,000 square feet of general purpose office space within reasonable distance of our present main location at 1520 H Street NW. This space is required to meet the following urgent needs:

1. Added employment within our current fiscal year 1960 authorization;
2. Added staffing anticipated if approval is obtained from the Congress to accelerate hiring against fiscal year 1961 authorization;
3. Full-time and temporary employment for a newly created Office of International Conference to coordinate and direct U.S. participation in the forthcoming conference on the peaceful uses of outer space.

Our future plans for leasing of office space depend now upon what GSA intends doing about our present urgent requirements. The 50,000 square feet which we are now attempting to obtain is intended to meet all agency needs until we occupy Federal Office Building No. 6, on about July 1961.

(Discussion off the record.)

Mr. FULTON. Could the committee have a statement regarding the promotions both in-grade and between grades in the past year and the estimates for the future? We would also like to have the total proposed cost of such promotions to the NASA agency and its budget for the respective fiscal years or parts of them.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Statement on within-grade salary advancements and grade promotions

Cost analysis	Actual fiscal year 1959	Estimated fiscal year 1960	Estimated fiscal year 1961
Within-grade salary advancements	$64,431	$182,000	$319,105
Promotions and reallocations	795,305	652,000	600,000
Total cost to NASA	859,736	834,000	919,105
Amount included in NASA appropriation request			319,105

Pursuant to Bureau of the Budget instructions, agencies were not permitted to request funds to finance anticipated within-grade salary advancements or grade promotions for the fiscal years 1959 and 1960. Funds to finance the salary adjustments indicated in the above table for the fiscal years 1959 and 1960 were realized through savings in personnel costs due to delays in filling vacated positions, leave without pay, delays in filling new positions, filling positions vacated at or near the top of a grade with new employees at the entrance step of a grade, and replacing vacated senior positions with new recruits at lower grade levels.

The estimates for the fiscal year 1961 include funds to finance within-grade salary advancements as now permitted by the Bureau of the Budget. The restriction against requesting funds for anticipated grade promotions continues in effect and funds for grade promotions will continue to be financed through anticipated savings during the fiscal year 1961 in the manner described for the fiscal years 1959 and 1960.

Under the original NASA Authorization Act of the 85th Congress there were provided certain numbers of personnel for excepted grade classes. Would you please put a statement in of those authorizations and also the method of filling them.

Mr. ULMER. Yes, sir.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
October 20, 1958.

Memorandum from the Administrator.

Subject: Establishment and approval of excepted positions and salaries under the authority of section 203(b) of the National Aeronautics and Space Act.

I. LEGAL BASIS

The National Aeronautics and Space Act of 1958 provides in section 203(b)(2) that "(A) to the extent the Administrator deems such action necessary to the discharge of his responsibilities, he may appoint and fix the compensation (up to a limit of $19,000 a year, or up to a limit of $21,000 a year for a maximum of 10 positions) of not more than 260 of the scientific, engineering, and administrative personnel of the Administration * * *"

II. STEPS TO IMPLEMENT THE PERSONNEL AUTHORITY

In order to provide a method of appointment to key positions in the new programs of the NASA as well as to assure the maintenance of the high morale level of those employees presently on our staff, the Administrator has approved the following items:

1. A policy statement of objectives regarding the use of positions established under this authority.
2. Salary intervals for positions established under this authority.
3. Administrative methods for selecting candidates and establishing positions to be filled under this authority.
4. Eligibility criteria for candidates for positions approved under this authority.

III. POLICY OBJECTIVES REGARDING USE OF POSITIONS ESTABLISHED UNDER SECTION 203(B) AUTHORITY

The positions established by the Administrator under authority of section 203(b) of the Space Act will be used solely to attract and retain the specially qualified scientific, engineering, and administrative personnel necessary to maintain this Nation's leadership in aeronautical and space activities.

1. It is the Administrator's objective to set the compensation for such positions at levels as nearly competitive as possible with the salaries the incumbents could be expected to command in the best modern research and development organizations in industry.

2. Identical criteria for selection to excepted positions will be used with respect to those formerly on the NACA staff and the new employees recruited for NASA.

3. The position and salary will be identified with the incumbent or prospective incumbent and will exist only during the period the position is occupied by such incumbent.

IV. SALARY LEVELS FOR POSITIONS ESTABLISHED UNDER THIS AUTHORITY

1. For not to exceed 250 positions, salary scales in the range of $14,500 to $19,000 will be established, initially in $500 levels. For not to exceed 10 other positions, rates of $20,000 or $21,000 will be established.

2. A minimum salary of $14,500 for positions under this authority has been adopted in order to provide for an increase beyond the top-of-the-grade rates being paid in GS–15 ($13,970). The Administration proposes to recognize, through use of 203(b) position authority, only those with a competence and level of responsibility clearly beyond what can reasonably be expected from employees at the GS–15 level.

3. Depending upon the particular eligibility criteria applicable to each individual, appointments may be made at any $500 increment level within the $14,500 to $19,000 range. It is an NASA objective to provide pay adjustments in recognition of performance rather than offer automatic salary increases through lapse of time.

V. METHOD FOR SELECTING CANDIDATES AND ESTABLISHING POSITIONS TO BE FILLED UNDER PROVISION OF THIS AUTHORITY

1. As a regular procedure, the Deputy Administrator, Director of Space Development, Director of Aeronautical and Space Research, and the Director of Business Administration will recommend to the Administrator the positions and individuals to be placed in the 203(b) category and the salary for each individual. Other officials reporting directly to the Administrator shall give him appropriate nominations of positions and individuals under their supervision who merit 203(b) recognition. In the consideration of appropriate salaries to be paid individuals, the Administrator shall also obtain the advice of the personnel director who shall also serve as secretary in any group deliberations to resolve questions on the administration of the 203(b) position authority.

2. The initial list of candidates for appointment to the excepted positions has been formulated by a careful ranking by the directors of the research centers and the top officials at headquarters of the individuals in order of their performance, contributions and future promise. These lists have been intermeshed by the Deputy Administrator and his principal subordinates into a consolidated list. This ranking procedure has taken into primary consideration the individual's capabilities and promise rather than simply the organizational level of the individual's position.

3. There will be review of all excepted positions, their salary rates, and candidates for such positions once each year. The purpose of this review is to assure recognition of individuals in excepted positions who have significantly increased their contributions and to consider individuals in GS positions who by their contributions and potential should be evaluated for possible appointment to an excepted position.

4. The recommendations to the Administrator shall be based on careful evaluation of individuals in terms of eligibility criteria recommended for each salary level. Recommendations will be made upon the basis of advice solicited from appropriate sources, such as the assistant directors, research center directors, administrative officers and other qualified persons who know the productivity and potential of the candidate and who can assess his contribution to the NASA.

VI. ELIGIBILITY CRITERIA

The specific determination of an individual's salary will be based insofar as practicable upon the application of the following criteria in assessing an individual's competence:

$21,000

Outstanding, internationally known, and distinguished scientists who direct the several broadest areas of aeronautical and space research or developments or occupy the highest positions in planning, evaluation, or direction of the Nation's program.

$20,000

Outstanding directors of the largest and most important research centers of major importance in the Nation's aeronautical and space research and development programs; or outstanding individuals in the most important top executive or staff positions of the administration.

$19,000

Scientists or administrators who head major broad research, development, or administrative programs, who are nationally known to have had a major influence on their broad areas and who rank with the top few experts in their areas of research, development, or administration. Also independent, internationally known scientists or other key staff officials or executives who have a personal record of sustained and distinguished major contributions which have had far reaching influence in their field.

$18,500

Individuals who both by their direction of important research or development programs and by their own contributions and leadership in a scientific or other area are recognized as being outstanding leaders in their field.

$17,000 to $18,000

Outstanding heads of important research, development, or administrative programs who have made substantial contribution of broad influence in their field of work in a manner which has earned them a national reputation of high standing and promise.

Independent consultants and authorities in specialized research, development, or other areas, whose work and contributions are well known both in this country and abroad and who are considered among the few top specialists in their fields.

$14,500 to $16,500

Heads of either broad or highly specialized research or development programs (including independent researchers of exceptional talent) whose contributions have received at least national recognition and whose potential for growth in the broader and more significant scientific or development areas seem sure.

Also heads of key administrative or technical service programs or other key staff assistants whose outstanding performance in the direction of their program is unquestioned and their promise of future growth seems certain.

An individual will be placed in the lower, the intermediate, or the upper level of any of the two above-salary ranges in accordance with a determination of his maturity, his previous rate of advancement and his relative value to the administration in relation to the individuals who are in the same class level.

Many, though not all, individuals of superior talent, ability, and creativeness naturally tend to be placed in organizational positions of increasing importance and level. By this means the organization seeks to widen his capabilities for contribution by enabling him to work through and be assisted by others. Thus organizational level tends to be an indication or correlate of ability but no automatic assurance of continued excellence. Therefore, evaluation for assignment to excepted positions and salary levels shall be determined primarily in relation to the competence of individuals rather than to the organization levels at which the incumbents may be working.

Accordingly, it will be expected that there will be a considerable range of as much as $2,500 in the salaries paid individuals with presumably equal organizational status. For example, top leaders of broad NASA activities will be compensated at maximums ranging to $21,000; the maximum for division chiefs in excepted positions will be up to $18,000; the maximum for assistant division chiefs in excepted positions will be up to $17,000; and the maximum for those branch chiefs in excepted positions will be up to $16,000.

VII. OTHER RELEVANT INFORMATION

The positions covered by this policy are excepted for pay purposes from the provisions of the Classification Act of 1949, as amended, but the incumbent of any excepted post retains such tenure, retirement, and status rights in the competitive civil service as the incumbent may have acquired prior to his 203(b) appointment.

The Comptroller General has ruled that the previous section 313 NACA positions must be absorbed within the new section 203(b) NASA authorization. Arrangements have been made to transfer all such incumbents immediately.

There are now 20 individuals transferred to NASA from NACA who hold GS–16 positions. The Civil Service Commission has informed NASA in line with their practice for other agencies in the past, that we will not retain these GS–16 positions if we remove any of the individuals from GS–16 for appointment to an excepted NASA position. Their justification for this policy is that the Congress in giving an agency a special agency package of supergrades or excepted positions

intends this special authority will meet the entire needs of the agency. NASA as a matter of policy will move into excepted positions any present GS–16 incumbents as they are judged on the basis of the above eligibility criteria to merit salary advancement beyond that available within the GS–16 salary range—$14,190 to $15,150.

T. KEITH GLENNAN, *Administrator.*

Mr. BERESFORD. Mr. Chairman, Dr. Newell is here to answer any substantive questions the committee may have concerning the Goddard Space Flight Center and Wallops Island Station.

Mr. FULTON. Why don't we have Dr. Newell give us a statement of the reasons for the expansion at various facilities? That is, the programs, the expenses that are necessary by way of salaries, and these various incidental expenses, that are reasonably caused by such an expansion of programs?

Don't do it now.

Mr. KING. Let me say this: Do any of you other gentlemen have prepared statements that you would like to give at this time?

Mr. ULMER. No, sir, Mr. King. We are here to answer your questions.

Mr. KING. We appreciate that very much.

Dr. Newell, will you get into the record then a short statement along the lines of Congressman Fulton's request?

Mr. NEWELL. Yes, Mr. Chairman.

Mr. KING. Stating briefly, in fact, you might just have a few sentences on each one of these items. I know this committee has received testimony on these before several times, but in order that it might appear in our particular record in outline form.

Mr. NEWELL. Yes, be glad to.

Mr. KING. So that it will be easy for us Congressmen to go to one place and get the material that we need to prepare ourselves for this particular aspect of the total budget.

Goddard Space Flight Center

Personnel strength, June 30, 1960	1,214
Requested personnel strength, June 30, 1961	2,000
Fiscal year 1961 increase	786

The personnel increase of 786 positions at the Goddard Space Flight Center is required by 2 considerations, one of organization and one of program responsibility.

The center is a new laboratory and as such drew its initial staffing from the highest professional levels of the former NACA, the Vanguard team of the Naval Research Laboratory, and from other Government and non-Government sources. The initial staffing formed a cadre of scientific experience and talent upon which to build professional teams. Since the center is at present operating in small, diffuse groups at four different locations, the required administrative and technical support can be bought as services from the host organizations. During fiscal year 1961, however, the center will begin to occupy its own laboratory facilities at Beltsville, Md. There, in a centralized and coordinated environment, the center can best carry out its three missions: the sounding rocket, earth satellite, and manned space flight programs. Effective execution of these programs by the professional staff requires an adequate number of supporting personnel. Where the current ratio of professional to supporting personnel is 1 to 0.8, the fiscal year 1961 position is expected to be 1 to 1.3. This increase will free the technical staff from administrative functions not properly in their fields, will provide a self-sufficient laboratory operation, and will provide the needed manpower to carry out the increased program assigned to the center.

During fiscal years 1959 and 1960 both the center and the NASA were just entering the field of space exploration. During fiscal year 1961, however, the major program results will begin to be evident. The program responsibility

is increasing; some $190 million will be directed or spent by the center during fiscal year 1961. The number of high-altitude rocket soundings will increase from 35 to 90 per year. Four major geophysics payloads, a lunar probe, a meteorological and a communications satellite will be completed, launched, tracked, and will yield data for analysis. Ten other major payloads will be under development. The most vital steps of Project Mercury, including manned orbital flight, are planned. Lack of personnel in any of these areas could hold the program below the known technological capabilities and scientific needs.

Wallops Station

Personnel strength, June 30, 1960	225
Requested personnel strength, June 30, 1961	300
Fiscal year 1961 increase	75

The reasons for the modest personnel increase requested for the Wallops Station are closely tied to the program evolution that has taken place over the last 18 months. During fiscal year 1961, Wallops will be called upon to launch, track, telemeter, and recover about 50 percent more sounding rockets than before. The first scout vehicles will be available for satellite and probe launchings. The Bermuda tracking stations, tied in as part of the Mercury network but manned by Wallops, will be coming into operation for the first time. These are considerable increases to the Wallops workload, with no compensating reduction elsewhere. It is this increased workload that requires additional staffing.

Mr. Beresford, do you have some questions that you would like to ask at this time?

Mr. BERESFORD. Yes, Mr. Chairman.

Mr. FULTON. Just before you start into that, may we go off the record.

(Discussion off the record.)

Mr. FULTON. Would you please supply for the record a job classification that would apply at the top level, just under the Administrator and Deputy Administrator, to the program formation responsibility, particularly in reference to the duties of Dr. Abe Silverstein?

I would ask for another job classification on the carrying out of the responsibility of carrying-out programs which is now under the designation of Associate Administrator and the designated responsibility of Richard Horner on appointment by the Administrator? That is all I have.

Mr. ULMER. I will be happy to supply those position descriptions for the record, Mr. Fulton, together with a copy of the letter Dr. Glennan is preparing on the general subject of the additional statutory position which you discussed in an earlier hearing.

Mr. KING. Mr. Beresford.

Mr. BERESFORD. Mr. Chairman, this subcommittee was asked by the committee chairman to consider the provisions for variation in this bill, in addition to the salaries and expenses items. I would like to ask Mr. Ulmer whether the provisions for variation in this bill are identical to those in H.R. 7007 of last year and, if there are any now provisions, what they are, so that the subcommittee could consider them.

Mr. ULMER. Mr. Beresford, the provisions for variation are identical to those included in last year's bill. There is one new item, section 9–D, on page 3 of the bill before you, which would permit the Administrator, for emergencies and extraordinary expenses, to use up to $20,000 of the research and development appropriation.

This is the only new item in the bill.

Mr. FULTON. Could you refer to those provisions exactly in each case so that we have the wording at this point in the record.

Mr. ULMER. Yes, sir. Section 9–D reads as follows:

Appropriations for research and development may be used in any amount not to exceed $20,000 for emergencies and extraordinary expenses upon the approval or authority of the Administrator and his determination shall be final and conclusive upon the accounting officers of the Government.

This is H.R. 10246, Section 9–D. This is authority that is substantially identical to authority contained for many other agencies of the Government, Mr. Fulton.

Mr. FULTON. Now then, the previous authority, could we have that mentioned?

Mr. BERESFORD. May I ask first about this one?

Mr. FULTON. I would like both the provisions put together so you can see them.

Mr. ULMER. This is a new one, sir, this did not appear in last year's bill.

Mr. BERESFORD. Is this identical in every respect to the authority granted other agencies, including the $20,000 limit?

Mr. ULMER. I am not sure of the exact amounts. I know it is certainly not in excess of that available to other agencies. The AEC, for example, has $30,000 available for this purpose.

Mr. BERESFORD. What is the reason for the provision? Just to provide for additional breakthroughs?

Mr. ULMER. It is to provide the Administrator with a very modest fund for representation allowances, and for expenses involved in consultation with foreign scientific officials primarily.

It will be mainly used to cover expenses involved in the visits of foreign scientific dignitaries. "Extraordinary expenses" refers to those not budgeted for and not otherwise authorized, but deemed desirable by the Administrator personally.

Mr. BERESFORD. In answer to your earlier question, Mr. Fulton, the other provisions for variation are these:

(c) Appropriations for "research and development" may be used for any items of a capital nature (other than acquisition of land) which may be required for the performance of research and development contracts: provided, that none of the funds appropriated for "research and development" pursuant to this act may be used for construction of any major facility, the estimated cost of which, including collateral equipment, exceeds $250,000, unless the Administrator or his designee notifies the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate of the nature, location, and estimated cost, of such facility.

(d) Appropriations for "research and development" may be used in any amount not to exceed $20,000 for emergencies and extraordinary expenses upon the approval or authority of the Administrator and his determination shall be final and conclusive upon the accounting officers of the Government.

(e) When so specified in an appropriation act any amount appropriated for "research and development" and for "construction and equipment" may remain available without fiscal year limitation.

SEC. 2. Authorization is hereby granted whereby any of the amounts prescribed in subparagraphs (1), (2), (3), (4), (5), (6), (7), (8), (9), of subsection 1(b) may, in the discretion of the Administrator of the National Aeronautics and Space Administration, be varied upward 5 per centum to meet unusual cost variations, but the total cost of all work authorized under such subparagraphs shall not exceed a total of $122,787,000.

SEC. 3. Any amount, not to exceed $5 million, of the funds appropriated for "Construction and equipment" pursuant to this act, may be used to construct, expand, or modify laboratories and other installations, if found by the Administrator to be necessary because of changes in the national program of aero-

nautical and space activities or new scientific or engineering developments and if the Administrator determines that deferral until the next authorization act would be inconsistent with the interest of the Nation in aeronautical and space activities, and in connection therewith to acquire, construct, convert, rehabilitate, or install permanent or temporary public works, including land acquisition, site preparation, appurtenances, utilities, and equipment: *Provided*, That upon reaching a final decision to implement, the Administrator or his designee shall notify the Committee on Science and Astronautics of the House of Representatives and the Committee on Aeronautical and Space Sciences of the Senate of the cost of such construction, expansion, or modification including those real estate actions pertaining thereto: *Provided further*, That no such funds shall be used for construction, expansion, or modification if authorization for such construction, expansion, or modification has been previously denied by the Congress; and additional appropriations are hereby authorized for purposes of this section in the amount of $5 million.

Mr. FULTON. Then you have the provisions for variation in the original act. Let's put that in the record so that we can have the whole setup.

Mr. BERESFORD. Yes, sir.

There are a couple of items I noticed in looking over the budget book. One is the considerabie, relatively great increase in the cost of travel. That is five-fold, I notice for fiscal 1961 over fiscal 1959.

Mr. Ulmer, you did say that that was largely accounted for by the ABMA transfer.

Why would so much more travel be required?

Mr. ULMER. First, Mr. Beresford, your statement of five-fold is correct in comparing 1961 to 1959.

Mr. BERESFORD. Yes.

Mr. ULMER. The current allotment for the fiscal year 1960, however, is $2.866 million which we are asking be raised to $5.849 million in 1961; that is slightly more than a two-fold increase.

The major item of increase here is $1.28 million for travel for the 5,500 people being brought over with the Huntsville facility. We are required in 1961, to pay for all of their travel costs.

Mr. BERESFORD. No matter where they go?

Mr. ULMER. Regardless of where they go.

Mr. BERESFORD. And you base that on experience of previous years at Huntsville, that is their expenses of previous years?

Mr. ULMER. Based on their experience in previous years, plus our estimate of their travel needs required to carry out their NASA mission. The other item of increase comes about because of the increased travel needs for the Goddard Center where we are activating tracking stations for the first time in 1961. This will involve considerably more travel.

Mr. BERESFORD. One other thing: I noticed on page 40 an item for research contracts, which was $816,510 for fiscal year 1959 and nothing for this or the next fiscal year. Is that because of a transfer from Salaries and Expenses to Research and Development?

Mr. ULMER. Yes, the $816,510 was the amount obligated by the NACA in the fiscal year 1959; in 1960 and 1961 these costs are carried under the Research and Development appropriation. The amount in 1960 is approximately $5 million and in 1961 it is approximately $10 million under the Research and Development section of the budget.

Mr. BERESFORD. I see.

Where do you include your expenses for nonscientific research, such as contracts for management studies or legal studies or anything of that nature? Are those Research and Development?

Mr. ULMER. Those are included under Research and Development, object 07, under the line item called "Support of Plant."

Mr. BERESFORD. Have you any oversea offices or personnel?

Mr. ULMER. Only to the extent that we have people located at tracking stations, no other oversea offices.

Mr. BERESFORD. How did you fund Project Mercury in the current fiscal year? Weren't there some transfers involved from other agencies?

Mr. ULMER. Not during the current fiscal year, sir. The money was entirely through appropriation.

Mr. BERESFORD. Just a couple of other things, Mr. Chairman.

In looking at this bill, I could not find any reference to Edwards Air Force Base. I see there is one up there on the chart. I suppose that is the flight research center in California?

Mr. ULMER. Yes.

Mr. BERESFORD. I don't know where that is in the bill.

Mr. ULMER. You will not see it in the bill, sir, because the line item authorization by location in the bill is for construction and equipment only, and there is no construction and equipment being requested for that station in 1961. The amounts shown on this chart are for salaries and expenses.

Mr. BERESFORD. I also found no reference to the Pacific Missile Range in the bill, although I saw in the budget book that you are evidently establishing an office there for the coming fiscal year.

Mr. ULMER. Yes. Again there are funds included under the item on the chart called "Liaison, Various Locations," which includes the salaries and expenses for about six people, I believe, at that station.

Mr. BERESFORD. Where does that appear?

Mr. ULMER. It would not appear in the line item authorization in the bill because there are no construction and equipment funds being requested for that office.

Mr. BERESFORD. Mr. Chairman, I have no further questions.

Mr. KING. Mr. Fulton, do you have further questions?

Mr. FULTON. May I thank the witnesses for their full cooperation and their hearty response to the questions of the Members of Congress sitting today on this committee as well as the cooperation of Mr. Spencer Beresford, our special counsel.

I would like also to note in the record the excellent job that has been turned in by the chairman on presiding this first time as chairman of a subcommittee.

Mr. KING. May I concur in your expressions of gratitude and appreciation of all those who have participated and assure you representatives of NASA that we shall do all in our power to defend these worthy items, and as far as we can tell, they are all worthy items. We will see that they are properly defended when they come up on the floor of the House and we appreciate your helping us get the facts so that we will be able properly to take care of them.

Mr. ULMER. Thank you, Mr. Chairman.

(Discussion off the record.)

Mr. KING. The subcommittee will be adjourned.

(Whereupon, at 3:30 p.m., the subcommittee adjourned subject to call of the chairman.)

[EXECUTIVE SESSION]

1960 NASA AUTHORIZATION

TUESDAY, FEBRUARY 23, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE NO. 3,
Washington, D.C.

The subcommittee met at 2 p.m., in room 214–B, New House Office Building, Hon. Victor L. Anfuso, Chairman of the subcommittee, presiding.

STATEMENT OF ALBERT SIEPERT, DIRECTOR, OFFICE OF BUSINESS ADMINISTRATION, NASA, ACCOMPANIED BY: WESLEY L. HJORNEVIK, DEPUTY DIRECTOR, OFFICE OF BUSINESS ADMINISTRATION; RALPH E. ULMER, BUDGET OFFICER; ROBERT G. NUNN, JR., ASSISTANT GENERAL COUNSEL; DAVID KEYSER, CHIEF CONGRESSIONAL LIAISON OFFICER

Mr. ANFUSO. All right, gentlemen. Let us resume these hearings. We have present here today Mr. Siepert?

Mr. SIEPERT. Yes, sir.

Mr. ANFUSO. Mr. Hjornevik?

Mr. HJORNEVIK. Yes.

Mr. ANFUSO. Mr. Ulmer, Mr. Nunn, and Mr. Keyser. Is that correct?

Mr. SIEPERT. Yes, sir.

Mr. ANFUSO. All right.

Let me ask you gentlemen this question: Does the NASA request the creation of additional excepted positions for use at the Huntsville Facility?

Mr. SIEPERT. We undoubtedly will. We have not officially as yet, but we will be submitting a request.

Mr. ANFUSO. And do you think that you will be doing that within the next few days?

Mr. SIEPERT. Yes, sir. We will accelerate our planning on that in an effort to meet your schedule.

Mr. KING. Will the gentleman yield?

Mr. ANFUSO. Yes.

Mr. KING. Will that change these figures?

Mr. SIEPERT. It will not change the dollar figures, no, sir.

Mr. KING. Why will it not change the figures?

Mr. SIEPERT. It will not actually change the overall number of people we ask for. The amounts of money that it will require over the GS–15, pay level which is what most of these people who would get these excepted positions are now paid, will not be a substantial sum. So we would not plan to submit a request for a change in the amount of personal services. Our personal service costs will be slightly more, but when you are dealing with a 5,500-man organization, the small increments that these would involve probably would not mean a change in the present submission of the budget.

Mr. KING. Thank you.

Thank you, Mr. Chairman.

Mr. ANFUSO. I suppose you are going to first clear your request with the Bureau of the Budget, is that correct?

Mr. SIEPERT. In accordance with our regular procedure, we would do that, yes, sir.

Mr. ANFUSO. Can you tell us now how many vacancies NASA has in the $19,000 and $21,000 positions?

Mr. SIEPERT. Only one, sir, I believe, and that is committed and held for Dr. Von Braun when he comes with us.

Mr. BERESFORD. Are you speaking of the $21,000 positions?

Mr. SIEPERT. No, I understood the chairman's question to be in the range from 19 to 21.

Mr. ANFUSO. No. The question is, how many vacancies you have in the $19,000 and $21,000 positions?

Mr. SIEPERT. I understand. You ask a twofold question: First, of the 250 positions which we may pay up to $19,000, how many are vacant?

Mr. BERESFORD. That is right.

Mr. SIEPERT. And second, how many are vacant in the range above $19,000.

Pardon me just a moment. I brought that material. Let me get it out of another document I have here.

Lets first start with the positions above $19,000, of which there are 10 authorized under the act. There are nine of these filled and the remaining one is committed and will be held so that we may raise Dr. Von Braun's salary when he comes with us.

Mr. ANFUSO. That one is in special reserve for Dr. Von Braun?

Mr. SIEPERT. That is right. All ten are committed.

Mr. ANFUSO. That completes that portion.

Mr. SIEPERT. Yes, sir.

Mr. ANFUSO. All right.

Mr. SIEPERT. Of the positions that pay up to and including $19,000, 199 of these have been filled and there are commitments to individuals pending on 10 others.

Mr. ANFUSO. That is 209?

Mr. SIEPERT. That is correct, as of February 23.

Mr. ANFUSO. How many will you have left?

Mr. SIEPERT. We will have 41 positions left, based upon that calculation. Now, against those 41, we are currently making 3 kinds of reserves.

First, we have just had a study completed for us by an outside group of scientists on what NASA should be doing in the field of biomedical sciences. There is a broad gap in research here, that is,

in terms of how does man adapt himself to the conditions of outer space flight. This is a part that is really not covered in our program at the present time.

Basically, in handling the Mercury Project, for instance, we are using present engineering knowledge, rather than developing new physiological or medical data, to assure the survival of the astronaut for the short period of time that is involved. This, then, represents a whole area that we have gone into very slowly because it could become very expensive or it could be poorly done.

Mr. ANFUSO. Have you started to work on that?

Mr. SIEPERT. We have just completed a study of the biomedical space sciences that I have not yet seen. But Dr. Glennan for the last 6 months has requested that we reserve 10 positions of the 250 so that we would be able to bring top-flight people into this field, if in fact that were our decision to start this program.

Mr. ANFUSO. That will further reduce the figure?

Mr. SIEPERT. That would reduce this 41 by 10.

Mr. ANFUSO. To 31.

Mr. SIEPERT. That is right.

Mr. ANFUSO. You have 31 left?

Mr. SIEPERT. That is right.

Mr. ANFUSO. What do you intend to do with those 31?

Mr. SIEPERT. In addition to this, the present staffing we have worked out in headquarters, the committee will recall I did present some reorganization of our headquarters staffing in order to take on this larger program now with Dr. von Braun coming. Our plans are that some, I believe it is 14, other specialty and technical jobs will emerge in headquarters that will be excepted positions.

Mr. ANFUSO. That would leave 17.

Mr. SIEPERT. There are three positions in the committed figures that I gave you which are already allotted by us to the Huntsville operation. So there are 3 Huntsville slots in the 209 jobs and 17 other positions, vacant positions, which will be made available to Dr. von Braun's group.

Mr. ANFUSO. That is already committed?

Mr. SIEPERT. That is right.

Mr. ANFUSO. That leaves you now another 14.

Mr. SIEPERT. In other words, to recapitulate then, of the 41 positions that are left we are holding 10 of those for biosciences program, 14 are tentatively shown against headquarters positions that have not yet been filled, 17 will be made available for the Huntsville group, and to this we add 3 in our presently committed group which are already allotted to Huntsville.

One other piece of arithmetic to round this out: The President's plan does provide that the supergrade or Public Law 313 positions from the Department of Defense's allocation, which are held by any members of the Von Braun team that are coming with us, these will stay with the men.

Mr. BERESFORD. They will?

Mr. SIEPERT. Yes.

Now, there are 19 such positions at the present time in the Development Operations Division. Eighteen of these under the present planning will be moving to NASA. The sole exception is Dr. Arthur

Rudolph, who is the Pershing project director and under the arrangements we have made with the Army, the man who directs the Pershing system will stay with the Army until that work can be completed. Then he will be joining us.

So there will be 18 positions that come over with the group when the transfer becomes effective.

Now, grouping those figures again, then, you have 18 transferring; you have 17 new positions, plus 3 which we have already committed to people, which is a total of 38 excepted positions that will be available to Dr. von Braun's group.

Mr. BERESFORD. They don't seem to be badly off.

Mr. SIEPERT. You mean with respect to Huntsville?

Mr. BERESFORD. Yes.

Mr. SIEPERT. Well, they will be better off than they were under the Army allocations, when they were competing with the entire Department of Defense.

One must also make the comparison of their staff against the rest of the NASA staff. This is, of course, where we feel a major obligation to see that this Huntsville group achieves the same kind of salary recognition as their competence would merit if they were working at one of our other research centers.

On this basis, the 38 jobs will give them, we figured out, about 3 percent of their total engineers and scientists in the excepted-position category. That is slightly less than is the overall NASA field experience, that is, in its other research centers combined.

(Discussion off the record.)

Mr. ANFUSO. Will all the excepted positions requested by NASA be filled with scientific or engineering personnel engaged in research and development?

Mr. SIEPERT. Of the additional ones we will ask for, yes, sir, I believe so.

Mr. ANFUSO. They will all be limited for these specific purposes, scientific or engineering personnel, not administrative?

Mr. SIEPERT. May I take a moment to answer that question? In terms of the future requirements we will be coming up with, this is probably correct. In terms of our past history, I would like to point out that a small proportion of these have been used for key executive personnel. It was the intent that they be covered by the National Aeronautics and Space Act.

I believe our requirements in this area covered 12 positions in the key executive areas, and at Huntsville, where we have a very major management operation, exceeding in difficulty that at any of our other centers, we are planning that three more positions which I would call key executive positions, will be excepted.

However, by the criterion of whether they are engineering or scientific, it happens that two of those three are technical engineers performing executive posts.

Mr. ANFUSO. Now, I would like to ask Mr. Nunn what are the purposes of subsection 1(d). Just give us a brief explanation for it, if you will. You had something in mind when you asked for that language. Is that correct?

Mr. NUNN. That is correct.

Mr. ANFUSO. I would like to know how you got the language and just how you arrived at that figure.

Mr. NUNN. Yes. I would be happy to.

The language in subsection (d) is derived from the similar provisions for the military departments. In the fiscal year 1959 Appropriations Act, for example, for the Army and for the Air Force and for the Navy, there are provisions for emergencies and extraordinary expenses to be used upon the approval or authority, in that case, of the Secretary.

Mr. ANFUSO. Are those words specifically used?

Mr. NUNN. The words that are specifically used are "emergencies and extraordinary expenses," and the phrase "approval or authority" in that case of the Secretary, and the phrase "shall be final and conclusive upon the accounting officers of the Government."

Now, those phrases come right out of military appropriations acts which are repeated every year.

Our purpose in adopting that language is that it was tried and tested language. We were not desirous of departing in some radical way from past governmental practice.

(Discussion off the record.)

Mr. ANFUSO. All right. Complete your answer for the record. You had other examples to give.

Mr. NUNN. I was simply going to say a word about the meaning of this, before getting to these other examples, Mr. Anfuso.

The phrase "emergencies and extraordinary expenses," we take to mean unusual and unforeseen expenses, in a budgetary sense.

In the administration of a program such as ours, occasions arise that call for minor small expenditures for which there is no clear-cut authorization or appropriation, and the fact that they may occur frequently doesn't mean that they are therefore usual. It means that these are unusual and extraordinary expenses in a budgetary sense.

For example, oversea representation allowances, which I think we understand the meaning of the term generally, are contemplated to be allowable under this provision.

Mr. ANFUSO. Not covered by counterpart, you mean?

Mr. NUNN. That is correct.

Consultation expenses and other expenses here in Washington with visiting scientists and governmental administrators of other governments, or, indeed, other private agencies within the United States.

Likewise, it should be pointed out that these unusual and unforeseen expenditures can be authorized under this provision only by the head of the agency.

Finally, let me say that the figure of $20,000 we regard merely as a modest figure.

Mr. ANFUSO. I would go further. I would call it petty cash in a billion-dollar corporation, or more. Isn't that right?

Mr. NUNN. I think in that light it becomes a rather small item.

Mr. ANFUSO. Well, it is very small.

Am I correct in saying that the Army, Navy, and Air Force, their figures run into $10 million or more?

Mr. NUNN. My recollection, Mr. Anfuso, is that the Army and the Air Force have funds respectively amounting to more than $5 million

each, and that the Navy has a fund similar to this in excess of $10 million.

Mr. ANFUSO. Am I also correct that the Atomic Energy Commission has a special provision similar to this where the amount is $30,000 specifically for entertainment purposes?

Mr. NUNN. That is correct.

(Discussion off the record.)

Mr. NUNN. I would like to direct your attention to Public Law 86–164, which is the Atomic Energy Commission Appropriation Act for 1960, which states, "For official entertainment expenses not to exceed $30,000."

That language is in their Appropriation Act.

Mr. ANFUSO. That is what I had reference to.

All right. Let me ask you one or two more questions, and then I will be through.

In other words, you are satisfied with that language, "emergencies and extraordinary expenses," which is taken from other appropriation acts; is that correct?

Mr. NUNN. That is correct.

Mr. ANFUSO. Now, on this personnel distribution, let me ask you a question which has been suggested by my esteemed colleague, Mr. Fulton.

How does NASA justify its present complement of legal, administrative, liaison, and public information personnel, and the concentration of its employees at Washington headquarters?

Now, who would like to answer that question?

Mr. SIEPERT. I would be glad to speak to it.

Mr. ANFUSO. Mr. Seipert.

Mr. SIEPERT. Our justification, I think, can be stated this way: If one considers the kind of technical operation we have to perform and then the numbers of people that NASA places in Washington to coordinate a technical program with administrative support that is spread all over the country, I think one will find that the concentration in Washington is very, very low for an independent agency.

Mr. ANFUSO. By comparison?

Mr. SIEPERT. That is right, in comparison with other Government agencies. But of the NASA total appropriations, less than one and a half percent of it goes into what might be called in the broadest sense, program direction or headquarters coordination. Even in that dollar figure is included the cost of our western office which is regionally carrying out certain kinds of coordination, liaison, and servicing function. It is feeding into the Washington headquarters certain program information. The total Washington operation, I believe, has a requirement of about 680 jobs for the entire headquarters.

If one compares this against 16,000 people which we now have, plus the 2,400 contract personnel at the Jet Propulsion Laboratory that are being used, as an extension of our inhouse capability to do hardware development, I think the committee would find that 680 in headquarters is actually a very conservative kind of staffing in order to keep on top of a fast-moving program such as this. We can furnish the committee a statement of how this headquarters-to-field ratio compares with some other agencies.

Mr. ANFUSO. Please do.

(The information requested is as follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Federal employment data for selected independent agencies—Data as of Dec. 31, 1959

Name of agency	Headquarters employment	Agency employment	Percent headquarters to total
National Aeronautics and Space Administration	[1] 533	[2] 9,804	5.4
	[3] 683	[3] 16,000	4.3
Atomic Energy Commission	1,677	6,620	25.3
Veterans' Administration	3,652	172,954	2.1
General Services Administration	2,555	27,326	9.3
Civil Service Commission	1,718	3,594	47.9
U.S. Information Agency	2,556	10,812	23.6
Federal Aviation Agency	3,000	34,500	8.7
Small Business Administration	503	2,122	23.6

[1] Authorized.
[2] Does not include Huntsville.
[3] Planned staffing for July 1, 1960, includes Huntsville. All figures except NASA are close approximates and do not take into account temporary or part-time employment. All figures for other agencies are as of December 31, 1959.

Mr. ANFUSO. Now, I am through.

Mr. Fulton?

Mr. FULTON. I had given a form to Mr. Beresford this morning. Do you have everything included?

Mr. BERESFORD. Yes.

(Discussion off the record.)

Mr. FULTON. Are we making adequate use in NASA of engineering and scientific talent, as an overall policy? Are you using the skills and the scientific know-how, rather than let it be diverted for other purposes?

Mr. SIEPERT. We believe we are.

If I may, let me speak about three aspects. First, the great bulk of our personnel, scientific, and technical, are as you know, in the field, actually in research laboratories or development centers.

In each of these centers it has been our policy to keep a continuous watch on utilization of skills. The director of each of the centers has set up a skills utilization group, we call it a personnel utilization committee, of top-level people in that organization.

Mr. FULTON. Do we have time to get a statement in the record on that, or do you want to take the time now?

Mr. SIEPERT. I will be happy to outline it briefly here. This has actually been an arrangement that has worked out very well. Second, with the cooperation of the Civil Service Commission, NASA's predecessor, the NACA, developed an entirely new series of position classifications that were built around the special skills of aeronautical research scientists.

By using these two tools intelligently, we have done a far—we believe—a far better pinpointing of the specific skills a man has and we have matched those skills with the job that he actually does. In other words, we aren't using what I would call generalized or shotgun position classifications. We are tailormaking them for the particular job a man can do.

With this system, it is much easier to see that a man is really developing along the line of his abilities rather than being put into a bypath that is of no interest to him.

The third aspect of the question relates to the headquarters operation in NASA.

You may recall that when we came before you a year ago and first announced our plans, Dr. Glennan made a point of the fact that he didn't see how a civilian space effort could operate with an effective utilization of the country's technical manpower, unless NASA could build in Washington an in-house capability of highly qualified technical and executive people who would be willing to make the tough program decisions, the go or no-go decisions as to whether to support this line of research or another line of research.

Now, if there were plenty of money, plenty of resources and plenty of people, we might not organize the program in this same way. We could consider supporting concurrent lines of approach, figuring out two or three possible ways to one goal, and then probably funding two or even all three of the possibilities, though maybe not at the same pace.

Now, we are trying to minimize the need for concurrent approaches. But to do it, we have got to be sure we have on tap in the headquarters the very best brains we can find to help choose where NASA is going to bet its money.

This is one of the reasons that you will find in our headquarters operation a fairly large number of excepted positions.

We have had to use these positions as a means of enticing really top quality, brilliant, and fortunately quite young people, as you may have seen from their coming and testifying before you.

Mr. ANFUSO. The people who are right here, I think they are all young men.

Mr. SIEPERT. These are some of the ones we are betting on to make sure we make as few mistakes as possible with the money entrusted to us.

Mr. ANFUSO. And in the long run that saves money, too, doesn't it?

Mr. SIEPERT. It should.

Mr. ANFUSO. Mr. Fulton?

Mr. FULTON. NASA then is a specific and a new kind of an agency that requires scientific know-how on deciding between the programs as to major policies?

Mr. SIEPERT. Yes, this is right.

Mr. FULTON. And it is much different, then, than another kind of an agency that is run more on principles that would involve the ordinary economics, the market and the rise or fall of prices and the prices of materials, for example? It is a much different kind of a decision being made by these executives, is it not?

Mr. SIEPERT. Yes, sir. One could operate the program so that someone at the headquarters level primarily makes administrative decisions, based upon staff work that had come in from industry, and chooses without technical review which industry proposal appears best, or which proposal from a research center.

Of course we do make such choices, but the one thing we have not thrown away is that we retain at headquarters independent technical people who, in the end, will take responsibility for saying which approach is the most likely road.

Now, we do not consider that administrative work. It is an essential part of the process of making informed technical decisions at the top level in an agency. Perhaps this may make our agency somewhat unique.

Mr. ANFUSO. Unique in that respect.

Mr. FULTON. What is your position in competition for scientists and engineers with private industry?

Mr. SIEPERT. The Government is still in a very poor position, to compete with industry for top-flight skills. I think the excepted position authority under the National Aeronautics and Space Act has been a help primarily in our keeping the people whom we have developed. It does not provide salary levels which permit us to go out and draw from industry the people who have equivalent or better competence than those that we have raised in our own laboratories.

Mr. ANFUSO. They can take away from you, but you can't take away from them; is that correct?

Mr. SIEPERT. Yes.

Mr. DADDARIO. Will the gentleman yield?

Mr. FULTON. Yes.

Mr. DADDARIO. If that is so, how do you correlate that statement with one you made just previously that you would rather do your own staff work rather than take the planning and staff work that comes from private industry if the people in private industry are more competent in certain areas than your people?

Mr. SIEPERT. I don't think I meant what my statement may have implied to you.

Mr. DADDARIO. You would have the skilled people who would make these great decisions and you would be doing the staff work within this agency which you say has to be here in Washington or should be here in Washington, and then your later statement was that you are not in good posture so far as competition for scientists and brains with private industry. And somewhere along back, you referred to the fact that you would rather not accept the staff work or the planning that comes from the staff work of private industry insofar as proposals were concerned.

Mr. SIEPERT. May I start with the last part of your comment?

Mr. DADDARIO. Yes.

Mr. SIEPERT. I want to emphasize that we do not feel it is a sound Government program for us to accept unreviewed those staff proposals which come from industry.

Mr. DADDARIO. How would they be unreviewed if you—you wouldn't be getting a staff proposal unless you had given industry some sort of a recommendation or given them some kind of an idea as to what you want.

Dr. von Braun before this committee mentioned the fact that he did have some kind of a hearing down South somewhere where a lot of industry representatives were, and he was impressed by the high order of their knowledge in this whole Saturn area.

They would submit plans and staff reports, I should imagine, only after knowing in which direction you people were headed. I don't think they are coming in arbitrarily from the outside.

Mr. SIEPERT. I am familiar with this industrial conference Dr. von Braun was talking about, since some of us helped his staff prepare

for it. That briefing conference was preceded by 1,200 man-hours of engineering analysis by Government people before that proposal ever went out to the industry. In order to establish just the point you make, the Government must first know what it is we want to ask for in these competitive proposals.

Now, when industry comes in with their proposals on the 29th of February, we will then have Government personnel go into a source-selection board procedure. It will take about a month for the Government people to be able to review and evaluate every assertion and proposal made by however many companies come in on that bidding.

This takes a very high order of technical competence.

Mr. DADDARIO. Then what you are doing is what I think you ought to be aiming at, correlating the skills that exist within industry together with those of your own.

Mr. SIEPERT. Yes.

Mr. DADDARIO. And you certainly are willing to take staff proposals from industry in order to help pursue your own work to a proper conclusion.

Mr. SIEPERT. I did not mean to suggest that we will do the complete blueprinting and merely tell industry: Build us a "bread box" that looks exactly thus and so.

No, this is a partnership of skills, but the Government cannot afford to put its reliance completely on industry to tell Government what is in the Government's best interest to do. This has to be a partnership in which our own people have the technical competence to judge these proposals independently.

Now, back to the other part of your question, if I may: The Government laboratories which have been created primarily under the NACA but now also under NASA, and the Army, namely, Huntsville, Goddard, Lewis, Langley and Ames, these, individually and together, represent a unique breeding ground for top-flight research and development engineers and scientists.

I would say it is unique in the sense that the opportunities that our people can get, in terms of physical facilities and type of projects available, or not equaled in industry.

If we can get people into that environment early enough and get them so enthused about the research and development work there, they will make Government a career, so long as the Government salaries do not lag too hopelessly behind industry. One of the Government's bargaining attractions is the intrinsic interest of the work and the quality of its facilities. This is a lever that outweighs, in part, the lower salaries that the Government has paid professional staff since the beginning of World War II.

Now the NASA has found that use of the excepted position pay scales makes it possible to recognize and keep engineering and scientific talent that has either come up through our laboratories, or, in some cases, has come up through the university world, which also does not pay industrial salaries, and yet those people from these two worlds have come with us and provided NASA the bulk of the technical competence we need.

So that while NASA does not in fact have true parity with industry and while we personally would of course like to have it, the NASA

excepted positions have certainly been a great help in minimizing this problem for our one agency.

Mr. DADDARIO. Thank you, Mr. Fulton.

Mr. FULTON. Sure.

Could you tell us how many you are losing on voluntary withdrawals from employment with the agency, and also how much of this erosion do you attribute to the ability of outside industry to compete at prices higher than you can pay?

You can put in a statement, if you want.

Mr. SIEPERT. I will need to supply that information, Mr. Fulton.

As a general statement, our erosion of technical personnel in the year immediately preceding the Space Act passage and in this past year has been quite small. I think this is understandable because the people have high motivation and participation in a brandnew program, and as a result the economic factors have operated less than they might in a more stabilized situation.

I shall supply that more detailed information to you, though.

(The information requested is as follows:)

STATEMENT ON VOLUNTARY WITHDRAWALS FROM NASA BY RESEARCH AND DEVELOPMENT PROFESSIONALS

During calender year 1959 out of an average number of 2,355 research and development professional personnel, NASA had 171 leave the organization voluntarily. This is a turnover rate of 7.2 percent.

It is our belief that the large majority of research and development personnel left because of pay. Our studies in the past have shown that in only a few cases did the individual leave for less or the same salary and those who went to industry usually received substantially higher pay.

Mr. FULTON. You do have the policy, do you not, to keep together scientific teams and put them on other programs when the programs either diminish or stop entirely?

Mr. SIEPERT. Yes, sir.

Take one research center as an example. Those of you who may have followed the Lewis Center, for instance, know this was an aeronautical propulsion center and the research spot for much of the advanced work on jet engines. In the program today you would find the same teams there, but, more than two-thirds of those teams are working on different research projects than they were as recently as 2 years ago, because they are now oriented very heavily into advanced propulsion systems as they apply to rocketry.

Mr. FULTON. I am interested, as you know, in boron and high propellant fuels. Could you put in a short statement on both boron and high propellant fuels? Are you going to use the people that we already have working on various aspects of that?

Mr. SIEPERT. Wherever possible, yes.

Mr. FULTON. So that the programs won't stop and, say, destroy communities.

Mr. SIEPERT. Yes.

(The information requested is as follows:)

STATEMENT FOR INCLUSION IN RECORD ON BORON AND HIGH-ENERGY PROPELLANTS

As stated in the testimony before the House Committee on Science and Astronautics on August 26, 1959, all the NASA work on boron fuels for airbreathing systems was terminated when the Department of Defense announced the can-

cellation of the zip fuels program. No new work at the research centers on boron fuels for aircraft has been initiated.

The only "in house" effort on boron as a rocket propellant is a one man effort at Lewis on the chemical kinetics of boron nitride formation. This is a basic study to determine the importance of boron systems for the chemical rocket.

In regards to the use of high-energy propellants in rocket systems, the NASA has extensive programs investigating hydrogen and fluorine and hydrogen and oxygen propellant combinations. This work includes study of propellant storage and handling problems, combustion chamber performance, nozzle performance, and heat transfer problems. To the extent possible, the personnel and technology utilized in the aircraft boron program, have been and are being utilized in this high-energy rocket program.

Mr. FULTON. The other point is this: Do you have a policy of trying to spread the NASA work in contracts as well as installations as much as you can through the whole United States?

I think that should be a specifically adopted policy. But other things being equal and where there is no particular reason for geographical location, that it all not be placed in one spot.

That applies to Pennsylvania, California, Colorado, New York, Massachusetts, wherever there are already installations, as in Virginia, and so on.

Are you trying to see that there is a fair share of this tremendous new business, and really, to me, a new economic way of life that is so tremendously based on science, that that is being spread equally?

The reason I say that is, you pick up any large metropolitan daily and you see tremendous offers being given by certain areas and certain companies, "Come here and you get everything."

Now, in the long run that may distort our distribution of scientific brainpower in this country and our scientific advances may be destroyed among various geographical areas, and likewise breaks up scientific teams already existing.

It has always been amazing to me that some companies who contract with the Government can offer so many advantages, and others along the same lines cannot. So that I would like some sort of a statement in the record on that, and particular reference to advertisements. I would like you to pick some of them out and comment on them.

Mr. SIEPERT. All right.

(The information requested is as follows:)

STATEMENT ON NASA PROCUREMENT

NASA follows generally the rules laid down in the Armed Services Procurement Regulations, which implement the NASA statutory contractual authority, the Armed Services Act of 1947, Public Law 413, and also the Federal Procurement Regulations, as promulgated by GSA, in the placement of contracts.

These, in part, provide that all procurement shall be made by formal advertising when possible, that competition shall be secured in negotiated contracts, and there may be set-asides for small business concerns or in labor surplus areas. In following these basic rules it is necessary to place a contract with the successful bidder on formal advertised procurement or the selected contractor on negotiated contracts, based on other factors than geographical location. There is no known statutory authority or regulation directing the placement of contracts based on geographical areas.

However, a review of 42 contracts of over $25,000 placed consecutively by NASA, detailed information concerning these having been given to members of the House Committee on Science and Astronautics in March 1959, showed that these contracts were placed in 18 different States including the District of Columbia. It is believed that subcontracts under these prime contracts spread out to several additional States.

A review of a few of NASA's larger contracts shows the following distribution of contractors' locations:

Scout space vehicle	Texas.
Mercury space capsule	Missouri.
Million-and-half-pound thrust engine	California.
Mercury tracking network (largely subcontracted to New Jersey)	New York.
Delta space vehicle	California and Florida.
Helium gas purifier	Massachusetts.
Mercury ablation shields	Pennsylvania.
Tracking station operation	Maryland.

It is therefore believed that NASA contracts do actually cover a wide geographic area.

STATEMENT ON INDUSTRIAL RECRUITING ADVERTISEMENTS

Industrial firms spend considerable money on advertising for scientists and engineers as is evidenced by reviewing any technical journal or the New York Times Sunday recruitment advertisements.

This industrial advertising influences our Government recruiting mainly through the fact that their advertising budgets are much larger than ours. We have not found that the fringe benefits offered by industry are featured in industry advertisements to any great extent. (See advertisements in the attached College Placement Annual for 1960.)

Government agencies have authority to advertise for personnel in shortage categories. NASA now has a limited recruitment advertising program. In these advertisements we are very conservative. The fringe benefits in Government civilian employment are such that we properly do not feature pay or fringe benefits, but rather transmit information on our research and development programs and depend on the appeal and excitement of the work to attract applicants.

Mr. FULTON. Some of those advertisements are simply amazing.

With my mathematics and scientific background, I wonder why I stay in Congress. If they give everything that they give in these companies, why should you be a Congressman to be paid a minimum pension which you pay mostly for yourself.

(Discussion off the record.)

Mr. FULTON. I am not speaking of contractors particularly with NASA, but certainly there is some difference between reality and this Alice in Wonderland thing that is pictured in advertisements, because it would make me think if I were working for one company and saw that there was another company that had these tremendous advantages on Government contracts that were not being fed down to me, that there was something either wrong at the top or something wrong with the Government.

Mr. ANFUSO. Are you through?

Mr. FULTON. Yes.

Mr. ANFUSO. Mr. Daddario?

Mr. DADDARIO. I will pass to Mr. King.

Mr. KING. I think the points have been mostly covered. This matter of salaries, though, intrigues me.

We have on occasions asked Dr. Glennan and others whether they felt that the total appropriation for NASA was adequate or whether they needed more money, a rather generous question.

The answer invariably was: No, we do not need more money. More money would be like pouring milk down the drain. We haven't the facilities to handle more. We are moving full speed ahead with what we have. More money would be largely wasted.

Now, this line of reasoning that we are engaging in now strongly suggests that the Government, being in the competition with private industry, perhaps would do better if it could increase the salaries in those higher brackets.

I realize you have said that up to now you have been able to compete reasonably well by giving very glamorous and challenging work, that you have been able to, to some extent, offset the salary differential.

But I am still left with the question whether or not the Government might not do a little better to secure and hold the tiptop men in science if these salary brackets were increased a little.

And I am further fortified in that hypothesis by the testimony of Dr. Von Braun, who said rather categorically, that in his opinion, to offer a top-flight scientist nineteen to twenty-one thousand, who could get twice that much, and then some, for comparable work in private industry, was not too realistic.

I wonder if you would like to comment on that?

Mr. SIEPERT. Yes, I would. If I can be a little autobiographical my comment may have a little more meaning.

Before I came with the National Aeronautics and Space Administration I was executive officer of another Government facility, the National Institutes of Health, which is in the medical research field.

About 3 or 4 years ago, I was asked to serve as a task force chairman for a committee set up under White House auspices to study what was needed to attract and keep scientists and engineers in the Federal service.

We did an attitude survey of about 17,000 scientists and engineers in Government research and development, which sample was a quarter of the total, and to get another benchmark, we did the same thing on about 3,200 technical employees, I believe, from nine industrial and nongovernmental laboratories. We asked exactly the same questions. We learned many interesting things.

First of all, the study confirmed the obvious idea that the scientists in industry and those in Government aren't much different in terms of what their interests and needs are. What is most important to them is how interesting and challenging is their research job, not the salary. The salary ranks fifth or sixth among the items that are most important to them.

Mr. KING. At least, according to them.

Mr. SIEPERT. According to them, who at the moment of this survey were not switching jobs. That is a very important point.

If you ask Government scientists after they have left the Government why they left, it is always money.

Now, this seems to be an inconsistency. In other words, if research interest is most important, then, why is it that you leave for money? One reason the study made clear: The greatest single point of difference in attitude between those in Government and those outside Government was on their prospects for salary advancement or promotion. The Government scientists and engineers were very pessimistic as a rule, while those in industry were generally optimistic as to their chances.

My personal hypothesis on this is that money and lack of promotion opportunity becomes more important when the interest potential in their work lags for some reason.

Mr. KING. Is it perhaps more important than they are willing to admit?

Mr. ANFUSO. Yes.

Mr. SIEPERT. It becomes more important than they have previously been willing to admit, once their children become juniors in high school. Then they get panicked about the cost of the college education, and all off a sudden they admit it to be a real problem.

This is one of the things Dr. von Braun has been worried about with his group. You see, that group the Peenemunde group came over late in 1945, I think it was. Many of that group did not marry during the war years. They married right after the war, and as a result their children are just now beginning to climb this ladder toward an expensive college education.

This entire German group places learning as the most important requirement for their children, as you know. I think this is the thing that would most worry Dr. von Braun and his leaders down there.

In connection with his study of this excepted position problem, we asked him: How many of your people have left you?

And he said: Of the 136 original scientists that came over, 116 in the first batch, and 20 more in 1948—all of whom had worked on rocketry in World War II—of these, 49 are no longer with the Government.

Now, it is for the committee to judge whether that is a serious loss or not to the Government. That is a one-third loss over about 10 years' time.

The only point here is: However many left, the prime reason for leaving they said, was that they had to get more money in order that they could be sure that their children really had all the advantages of education.

Mr. ANFUSO. And that was the answer every time?

Mr. SIEPERT. That is almost always the answer.

So returning to your question, Congressman King, yes, I personally believe an improvement in the salary structure for the Government, of its top technical personnel, would be very good economy for the Government. Then the Government could really be assured of its ability to have on board the people whose skills could best help reach the right decisions.

Mr. KING. I remember Dr. von Braun making the statement that for every $10 the Government spends on research and development, at least $1 should be spent inhouse for the $9 contracted out, so that the Government would retain enough technical competence to be able to deal with the contractors, to be able to get its money's worth.

And I believe your testimony has corroborated that statement.

Mr. SIEPERT. Yes. I am not quite sure whether Dr. von Braun meant that $1 should be spent directly by the Government checking, solely in monitoring and working with the contractor, versus $9 spent by industry, or whether he meant that there ought to be at least $1 spent to assure inhouse competence versus the amounts spent for out-of-house work.

I think he had in mind the latter interpretation. In the Huntsville operation, for instance, nearly 90 percent of the money is already on contract.

However, if we check how much of that remaining 10 percent for maintaining inhouse competence is actually used to work directly with industry and for checking that the industrial part of the program is going the way the contracts have specified, this would be a figure less than $1 out of $10.

Mr. KING. Thank you.

That is all, Mr. Chairman.

Mr. ANFUSO. Mr. Beresford——

Mr. FULTON. Just before you leave that point, I think you made a very good one.

Why don't we get the history of the Von Braun team and put it in the record at this point, as to personnel?

Mr. KING. I think so.

Mr. FULTON. Would you do that, Mr. Chairman?

Mr. ANFUSO. Yes.

Mr. KEYSER. I think that will be presented to the full committee in response to the question by Mr. Miller.

Mr. FULTON. I would like it right here at this point in the record.

Mr. ANFUSO. Without objection, it is so ordered by this committee.

(The information requested is as follows:)

HISTORY OF THE GERMAN ROCKET GROUP WHICH WENT TO THE UNITED STATES

I. PEENEMUNDE

The German Rocket Development Center at Peenemunde was an organization of the German Army ordnance and headed by a general. The civilian director was Dr. Wernher Von Braun who headed a development organization with laboratories, test stands, shops, etc., of approximately 4,000 to 5,000 people (the figure changed over the years). The major development successfully completed was the V–2 ballistic missile weapon system. Other developments were an antiaircraft guided missile, a longer range ballistic missile of the V–2 type, jato's for military aircraft takeoff, etc. The organization consisted of at least 150 Ph. D.'s, several hundred M.S. degrees and close to a thousand B.S. degrees. The rest were technicians, administrative personnel, skilled, and unskilled workers.

II. FORT BLISS, UNITED STATES

Following the close of World War II, 116 of the experts of the Peenemunde group were selected and invited to come to the United States under contract (Project Paperclip) and later on after having received immigration status were admitted into civil service. This group consisted of 25 Ph. D.'s, 34 M.S., 48 B.S., and 9 technicians, and was divided in about half; one group being stationed at White Sands Proving Ground and the other group at Fort Bliss. The White Sands Proving Ground group was in charge of assembly, testing, checkout, and firing of captured V–2's, and the Fort Bliss group worked on Project Hermes II, a winged ramjet to be boosted up by a V–2. The General Electric Co. was associated with either group as a prime contractor. Both establishments worked under Army Ordnance. As time went on, more and more of the German experts were withdrawn from White Sands and incorporated in the Hermes II project at Fort Bliss. In 1948 an additional 8 Ph. D.'s, 7 M.S., and 5 B.S. experts mainly from Peenemunde, totaling 20, were invited to the United States under contract (Project Paperclip). By 1949 the entire group (among them above-mentioned German experts) amounted to approximately 350 civilians and approximately 150 military, all working on Project Hermes II. Besides the German experts the civilians were composed of civil service personnel and contractor personnel (General Electric Co.).

III. REDSTONE ARSENAL, HUNTSVILLE, ALA.

In 1950, about 500 personnel moved to Redstone Arsenal, Huntsville, Ala., where Army Ordnance had closed down a chemical warfare and ammunition plant after the war. Here the group, under the name of Guided Missile Development Division, established offices, laboratories, shops, and test stands, continued on the Hermes II program and started the development of the Redstone missile. The Hermes II program was discontinued in 1953 and the group devoted their whole time under Brig. Gen. Toftoy to the development of the Redstone missile system. In 1952 an additional approximately 30 experts from Germany (mostly former employees of Peenemunde) were contracted under "Paperclip" and joined the group at Huntsville. In 1955 approximately another 40 people, partially under "Paperclip" and partially under "Project 63" joined the Huntsville activity under contract. By the end of 1955 the Guided Missile Development Division amounted to approximately 1,400 employees (in the meantime most of the original German group became American Citizens). On February 1, 1956 the Army Ballistic Missile Agency was established under Maj. Gen. J. B. Medaris and started development of the Jupiter missile system while continuing on the Redstone missile system. The Von Braun team became the Development Operations Division under the new Army Ballistic Missile Agency. A considerable build-up of facilities and personnel took place and by now there are approximately 4,200 civilians working directly under Dr. von Braun. Contracting of German and Austrian experts, especially under Project 63, continued through all these years.

On the other hand, many of the key scientists of the original German group (actually 49 of the original 136) have left for other agencies and mainly for employment in American industry. The major accomplishments of the Von Braun team through all these years were successful development of the Redstone missile system, Jupiter missile system, first U.S. satellite (Explorer I) and further Explorer satellites, first successful Moon shot and further satellites under Juno II program, development of ablation type nose cones for IRBM's and recovery technique, recovery of the first primates with a Jupiter nose cone, project Hardtack, and project Argus satellites, etc.

The current civilian staffing of the Development Operators Division is shown in more detail in the attached table. Data are given by laboratory, and by civil service grade. These figures do not include technical and management support personnel which are currently provided from other components of the Army organization at Redstone.

Development Operations Division—Distribution of Advanced Degrees Held by Scientific and Engineering Personnel

	Office of Director			Aero			Comp			F&AE			G&C			MFL			RPL			S&M			SA&R			SSE			Test			Totals		
	Total	Ph.D.	Master	Total	Ph.D.	Master	Total	Ph.D.	Master	Total	Ph.D.	Master	Total	Ph.D.	Master	Total	Ph.D.	Master	Total	Ph.D.	Master	Total	Ph.D.	Master	Total	Ph.D.	Master	Total	Ph.D.	Master	Total	Ph.D.	Master	Total	Ph.D.	Master
Public Law 313 and supergrade	5	2	2	1	1	0	1	1	0	1	0	1	3	1	1	2	2	0	1	1	0	2	0	2	1	0	1	0	0	0	1	0	1	19	8	8
GS–15	8	0	2	16	2	8	8	2	5	11	0	5	30	6	16	13	1	6	5	3	1	29	2	7	13	4	5	10	0	2	11	1	3	154	12	40
GS–14	16	0	2	13	3	6	9	1	1	14	0	1	49	7	17	11	0	5	9	3	1	55	4	15	19	6	0	20	2	10	10	0	0	225	13	25
GS–13	9	0	1	18	2	4	8	0	2	26	0	3	79	1	8	20	0	5	7	2	2	84	4	23	23	0	1	25	0	0	37	0	0	336	7	34
GS–12	4	0	0	19	1	4	14	0	1	14	0	0	67	0	5	23	0	5	7	1	2	48	2	10	13	0	1	10	0	0	14	0	0	231	2	23
GS–11	2	0	0	21	1	6	16	0	3	5	0	0	36	0	0	5	0	0	2	0	0	31	0	1	2	0	0	7	0	0	9	0	0	136	1	10
GS–9	1	0	0	16	0	3	20	0	1	5	0	0	34	0	0	11	0	0	1	0	0	32	0	2	11	0	0	9	0	0	5	0	0	145	0	6
GS–7	0	0	0	21	0	3	3	0	0	3	0	0	20	0	0	6	0	0	1	0	0	12	0	0	6	0	0	2	0	0	10	0	0	84	0	3
GS–5	0	0	0	4	0	0	4	0	0	0	0	0	4	0	0	8	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	23	0	0
Total	45	2	7	129	10	34	83	4	13	79	0	6	322	4	22	99	4	1	31	10	4	295	8	42	88	0	7	84	0	4	98	1	4	1,353	43	149
Percent of Ph.D's to scientific and engineering in each organization		4.4			7.8			4.8			0			1.2			4.0			32.3			2.7			0			1.0				3.2	
Percent of Masters to scientific and engineering in each organization			15.6			26.4			15.7			7.6			8.4			1.0			12.9			14.2			4.8			4.1				11.0	
Distribution of Ph.D's and Masters		4.7%			22.9%			8.9%			3.1%			16.0%			2.6%			7.3%			26.0%			3.6%			2.0%			2.6%		

Mr. ANFUSO. Mr. Beresford.

Mr. BERESFORD. I have only one question, Mr. Chairman.

I would like to return for a moment to subsection 1(d) of the bill, and ask Mr. Nunn whether I understand correctly that the $20,000 could be used for scientific conferences and consultations but that it would not be confined to that use, it could be used for any purpose which the Administrator found to be necessary?

Mr. NUNN. That is correct.

Mr. ANFUSO. To carry on the purposes of the agency.

Mr. NUNN. That is correct.

Mr. BERESFORD. No other questions.

Mr. ANFUSO. All right, if there are no further questions, then this meeting stands adjourned——

Mr. FULTON. Before we leave, I had been thinking over the personnel that you may have assigned to do liaison work with the military.

Do you have adequate staff to maintain adequate liaison with the military programs in the Department of Defense, ARPA, and the other agencies?

My question is really based on the adequacy of the personnel to fulfill the function of military-civilian liaison on programs that in many respects are in both fields.

Are you doing the job personnelwise in that field?

You can put a statement in the record on that.

Mr. ANFUSO. Can you prepare a statement?

Mr. SIEPERT. Yes.

Iwould like to answer this by saying that, yes, we have organized the staff in a way that this is done. One cannot, however, go through our staff organization and find jobs called "liaison." What we have done——

Mr. FULTON. I want that explained.

Mr. ANFUSO. Mr. Seipert, I think that is an important question which deserves a good answer.

Mr. SIEPERT. We will give you a statement.

Mr. ANFUSO. Which will show the overall picture. Thank you.

(The information requested is as follows:)

STATEMENT FOR RECORD

The National Aeronautics and Space Administration has organized and assigned its staff to carry out adequate liaison with the Department of Defense, the military services, and other agencies without actually assigning personnel to full-time liaison work. Because of the complexity of the aeronautical and space research and development activities and the belief that the best liaison is obtained at the working levels in the respective areas of endeavor on a day-to-day basis, the policy of the NASA is to assign the responsibility for liaison to the staff members as one of their normal duties. The NASA, of course, recognizes the need for continuous general liaison in the broad areas of mutual interest. This function is accomplished by appointing staff members from all levels to represent and to participate in the activities of the many management, scientific, project, and advisory types of committees that have been established for the purpose of insuring the exchange of information and coordination of programs of mutual interest to the NASA, DOD, and other agencies.

In general terms, the adequacy of personnel to fulfill the liaison function depends largely on the staff complement available to conduct the aeronautics and space activities of the NASA. The need for close and continued contacts with many parts of the Defense Department is a significant factor in determining requirements for headquarters staff.

52493—60——18

Mr. BERESFORD. When is this subcommittee going to reconvene?

Mr. ANFUSO. We will have to reconvene.

Mr. Siepert, you are going to supply us that information within the next couple of days, and then we will have to reconvene for that purpose.

Mr. SIEPERT. All right, sir.

Mr. ANFUSO. So that these hearings will not close until then.

Thank you, gentlemen.

(Whereupon, at 3:20 p.m., the subcommittee adjourned, to reconvene subject to the call of the chairman.)

1961 NASA AUTHORIZATION

THURSDAY, FEBRUARY 18, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE NO. 4,
Washington, D.C.

The subcommittee met at 2:05 p.m., Hon. B. F. Sisk, chairman, presiding.

Mr. SISK. The subcommittee will come to order.

We have been assigned a rather substantial portion of what amounts to almost a billion-dollar budget. The budget we will be responsible for is something over $250 million.

It is the Chair's opinion that, certainly as far as he is concerned, there will be no limination on time here, and I would hope everybody is in agreement. We want to pursue these problems diligently and learn as much as we possibly can about this because we are going to have to defend our position on the floor. So, when it comes to questioning, as far as the Chair is concerned, he feels that every member should have all the time for questioning he desires. The staff also will be allowed to ask questions and we will expect you to have some questions.

With reference to the time, there has been some discussion about how long we were going to be given to complete our part of the hearings. Here again it is the Chair's opinion that we will simply start in, we will do the very best job that we can, we will explore as carefully as possible every item, attempt to learn as much as we can and to justify these items. If it takes 3 days or if it takes 3 weeks we will continue to pursue it diligently until we have completed the hearing. That is the Chair's feelings about this matter because he feels it to be very important.

If any of the other members of the committee have any comment to make on procedure I would appreciate it.

This is not, of course, to say we do not wish to act expeditiously and, of course, to cooperate with the full committee, but it is the Chair's very strong feeling that we have a very grave responsibility here. The only way we are going to be able to fulfill it is to go thoroughly into these things and take such time as is necessary to do the job.

As far as I am concerned that pretty well lays the groundwork as I see it. If you have any comments to make on it, very well.

Mr. MCDONOUGH. I see none, Mr. Chairman, as far as I personally am concerned. I think they are fair rules, that we should abide by them and that we should exhaust every possibility to get every bit of information that we can.

There is one thing I think may develop as we go along. This is an open session and there may be information involving security matters. I wish that anyone who is testifying would inform us if such is the case. We have no security officer here, do we?

Mr. SISK. Not so far as our committee is concerned, other than we will depend on Mr. Wilcove and Mr. Hines, our consultants, to guard against security violations from our standpoint. The people testifying for the agency will, I am sure, be fully alert to that also.

Mr. MCDONOUGH. The questions the members of the committee may ask, in all due respect to revealing as much as possible and keeping the public informed, I think there are certain things, and I think we could make better progress, if we didn't reveal them, because this information gets into disloyal hands from loyal hands very rapidly.

Mr. SISK. I agree with what my colleague has to say. I might say now our subcommittee will hear later from the Atomic Energy Commission witnesses. As you know, AEC was scheduled to appear before the full committee tomorrow, I believe, but that has been canceled. Our subcommittee has now been designated to hear the AEC witnesses. We will hear them next week.

Has that date been set? I am advised by Mr. Wilcove that they will testify next Friday.

At that time, they will be prepared to give us a statement in open session and will also be prepared to make further comments in closed session. So we will probably have both an open and an executive session in order to get all the information we need.

The same thing is true, I might say to you gentlemen and others who may be appearing from NASA. We want to keep as much of the hearings open as possible and to make public everything we possibly can because we feel we need the support of the public. It is public business.

On the other hand, if, from time to time, you feel it is necessary, in order to give us the full picture, that we do go into executive session we will simply have to do that. I will appreciate your suggestion, if in our questions we move into an area where, because of the military aspects of it, which of necessity may occur, that you just simply state that is something we should take up in executive session, and we will do so.

Unless some other member of the committee has a comment, we have with us today as witnesses, Mr. Richard E. Horner, the Associate Administrator, who has with him Mr. Wyatt, Director of Program Planning Coordination, and Mr. Hyatt, Deputy Director. We also have Mr. Finger and Mr. Mitchell.

STATEMENT OF RICHARD E. HORNER, ASSOCIATE ADMINISTRATOR, NASA

Mr. HORNER. Mr. Chairman, I do not have a statement for the committee. We have here today program directors, experts in each of the program areas covered by our budget allocation and we are prepared to answer any questions on the budget matters that are in this particular section of the budget at the will of the committee.

Mr. SISK. It is my understanding that our subcommittee will be dealing with the latter part of research and development.

The first program is vehicle systems technology. I assume, Mr. Horner, from what you have stated that you have someone with you who is prepared to make some specific statement on this vehicle systems technology program, with some justification of the request, or do you just want us to go to questions directly?

Mr. HORNER. We have planned no specific statements beyond what appear in the backup books that have been furnished to the committee, Mr. Chairman. We can speak to each of the line items as they are mentioned or we can respond to questions of the committee.

Mr. RIEHLMAN. Mr. Chairman, in view of the fact that we are not proficient in this field I think it would be well it someone qualified addressed himself to each section. It will give us at least a briefing so we can ask intelligent questions. I don't feel under the circumstances I can thumb through here and come up with questions that I would be satisfied with until we have had some briefing on each section. If we have the men qualified to do it I think we would expedite our work and be better informed if it could be handled that way.

Mr. HORNER. We will be glad to do so if its is the desire of the committee and I would suggest the best way to do this is to take the line items as they appear for this first section on page 170, of the book and just start with the top line item. We have the qualified program people in for each one of these line items. In this first section the bulk of the program is under the jurisdiction of the space flight development part of our organization. Mr. Wyatt is the program director in that area and I would ask Mr. Wyatt to start off running down these line items, then.

Is that responsive to your suggestion, Mr. Riehlman?

Mr. RIEHLMAN. That is responsive to my suggestion because I just feel we have to have that type of indoctrination before we are in a position to ask intelligent questions.

Mr. HORNER. I would ask Mr. Wyatt then to start off with the top line item and we will have other people augment his comments as they go along.

Mr. SISK. I might say to my colleague from New York that is more or less what I had in mind because we are going to need a little briefing here on these, item by item.

Some of these items are rather small. On some of the larger ones, there is no question but that we will spend more time on them, but I do think Mr. Horner, that we should have at least some justification and some comment from your people who are directly in charge of these particular things.

Under the first section here, whoever is qualified to speak please proceed then and briefly outline these items as they are outlined here on page 170. I think that would be fine.

Mr. HORNER. I would make one further suggestion, then, Mr. Chairman: The budget justification as it appears in this book tends to be cast in somewhat technical terminology and I will caution my colleagues then to provide adequate definitions for the terminology as they go along. Such things as injection guidance and so on.

STATEMENT OF D. D. WYATT, ASSISTANT DIRECTOR FOR PROGRAM PLANNING AND COORDINATION, OFFICE OF SPACE FLIGHT PROGRAMS

Mr. WYATT. This is something of a catchall section because it involves a number of specific areas relating to space flight in which we must advance the state of the art beyond where it is today. In other words, we do not have completely satisfactory and completely desirable guidance systems, structures, even materials. And the specific line items in this category are intended to augment or start as the case might be, work in a number of these related and yet different areas of technology.

Now, for example, the first three or four items are all related to guidance and control. This, of course, is one of our areas of greatest technological concern insofar as a satisfactory flight is concerned. That is the problem of being able to place the space vehicle into either the designed orbit if it is going to become an Earth satellite or into a desired trajectory so it can either come close to or impact on the Moon or the nearby planets as the nature of the shot may be.

To achieve this guidance system technically there are several steps that can be taken. First off, we have this first line item referred to as "Injection guidance."

Now, this refers to the guidance system which is carried in the basic booster vehicle, and by which, one might say, you line the gun up at the instant the shot leaves.

In other words, when our spacecraft leaves the powered phase of flight, after the first stage and the second stage and if necessary the third stage booster burn out, we would like to have it, if possible, pointed exactly on the trajectory that will lead us to the target. Let us say we are talking about a Moon shot. We would like to be able to just let it fly along a free flight path after the rockets burn out. To do this we would have to have an extremely accurate, injection guidance system or a system which guides it, points it, and get the velocity just right at the instant of burnout. This is the so-called injection guidance system. And the specific sums—$1.8 million referred to here for fiscal year 1961, are to continue work on improvements in components of the injection guidance system so that we can improve that accuracy to the greatest extent possible.

Now, we find that in general it is impossible to rely entirely on the injection guidance to make a satisfactory flight. In other words, a very, very tiny error at the moment of burnout in either direction or velocity can result in a very large miss by the time you get to the Moon. It is like duck hunting. You are leading the Moon, the Moon is over here when you fire and you have to aim exactly so that your trajectory gets the vehicle to the location of the Moon when the Moon gets there. But if you miss your velocity a little bit, obviously you can either run ahead of or behind the Moon at the time you cross its orbit. Or if you miss your angle a little bit when you get out there you will either be ahead or behind it.

So what we generally find necessary and desirable is to augment the injection guidance with some later guidance someplace along the flight path and there are several of these categories of later guidance systems that can be used. One of them we call the midcourse guid-

ance system. In other words, we guide the vehicle as accurately as possible through burnout and then we check its actual course for some period of time until we can verify through data transmission, through Doppler radar and this sort of thing exactly what course is it on and how far is off from the velocity or angular condition that we desire.

And then if we have provided the equipment known as midcourse guidance equipment in the package we can then radio out an instruction that says, "Fire the rocket for so many seconds to increase the velocity by a certain desired amount." Or it may be what we call a *retro-rocket or an opposing rocket to slow it down a little bit.* Or we say, "Fire some control rockets and change the angular path a *little bit.*"

By doing this it is as if when you were hunting ducks, after you shot and when the shells got half way up to the duck you had time to look at it and say, "No, I'm leading it too much," and then had a way of instructing the bullets to veer a little bit to their left, you would make more certain you would intercept the duck.

This we can do with the equipment known as midcourse guidance equipment and this is the line item we have here of $1.3 million for 1961, for specific research into the components that we will hope in the future will enhance the accuracy of our midcourse guidance systems.

Mr. RIEHLMAN. Mr. Chairman, is that just in the research stage at the present time?

Mr. WYATT. This $1.3 million is for advanced work. In other words, we do have some midcourse systems under actual development but we need continually to try to improve the components of the systems, the sensors, the actual control jets, everything about the system.

Mr. MCDONOUGH. You had $50,000 for last year.

Mr. WYATT. Yes, sir.

Mr. MCDONOUGH. Was that the first money you had for the midcourse guidance system?

Mr. WYATT. The first money that the NASA had—you appreciate we only came into existence in 1959. There was work conducted at the Jet Propulsion Laboratory during fiscal year 1959 but because of a change in our method of allocating moneys that money does not show here in this makeup. Actually, there was money specifically for that in 1959 as well as in 1960.

Mr. MCDONOUGH. Now, in your injection guidance program you had $3,804,000.

Mr. WYATT. Yes.

Mr. MCDONOUGH. And you have made some progress along that line?

Mr. WYATT. We are tapering down for the reason that each specific vehicle that we have under development, has a special injection guidance problem. It is part of the basic vehicle and hence the bulk of our work is actually reflected budgetarily in the support, say for the development of the Centaur vehicle, the development of the Saturn vehicle, the development of the Scout or Delta vehicles. Each of them contain items for the development of the specific guidance system for that particular vehicle.

The money in the general area is not aimed at a specific vehicle but toward improving the state of the art generally.

Mr. SISK. That is of the first four?

Mr. WYATT. Yes.

Mr. SISK. When we get to the fifth one——

Mr. WYATT. Then we go to a specific spacecraft system.

But, may I first spend a few moments on this so-called terminal guidance system. Even after we aim as well as we can at the moment of burnout and even after we correct in the midcourse, we still do not, potentially in the future, have as accurate a guidance system as we might want. Again, let me use a lunar flight for an example: If all we wished to do is to impact the Moon someplace, we probably can do it very well with a combination of improved injection and midcourse guidance systems. In other words, we can steer it well enough to hit the Moon. But let us look some years into the future when we are going to be concerned with, say, landing a man on the Moon. In that case we will want to preselect a specific site. We will want to make sure it is not on the side of a mountain or in the crater of a volcano but rather in a relatively free, open area. Where it is relative to the available sunshine at the time of the flight will be important so we don't land him on the dark side of the Moon or anything like that.

This means we have to make a final course correction as we approach the Moon, and by one technique or another, localize the impact point down to the desired point. We do this by what we call a terminal guidance system. In other words, the end-of-flight guidance system. This involves little control rockets carried along in the space vehicle and a sensor system that can be anything from a simple horizon seeker system, where we have devices to tell us, "These are the edges of the Moon and we will line up and land at the center of the edges," to a television camera in the spacecraft and a ground observer back on the Earth observing the picture and by radio signal commanding the spacecraft to change its course a little bit until he sits it down on the desired spot.

This is what we call the terminal guidance system but it completes the system. First you aim it as well as you possibly can. Then you correct it as best you can while it is flying out toward the target and then finally you make a fine correction to it just as it approaches the target so that you can land it.

Now, this work is just getting started in fiscal year 1961, and the moneys we are requesting here in the general area are relatively small, about a quarter of a million dollars. This again is because—well, these guidance systems do have a bearing one on the other. Some of the components developed for one can be used in the other and we feel that we want to get started here, but our needs for this specific system are somewhat downstream in time and hence we are not putting as much emphasis at this time on the general research and development of the terminal guidance area.

Then we come to this item called attitude control systems. This is related to, but it is a little different from guidance. The attitude control system refers to this.

Let us say this cup is a spacecraft I desire to land on the Moon. Well, obviously I don't want to land on the Moon sidewise nor do I want to land on the Moon and be drifting at the time I land so I have to put in what is known as an attitude control system. Something that if the vehicle starts to tip, senses that it is not vertical and erects

it again. Something that if it is drifting, senses it is drifting and puts a side force in to make it hover and drop.

In actual space flight—that is not approaching a lunar surface, for example, we may have to rely on solar cells, arrays of solar cells for power. As we fly we will find it necessary to continuously keep the vehicle pointing so that the solar cells are pointing at the Sun all the time in order to get maximum solar energy. This again is part of what we call the attitude control system. In that case we keep the vehicle pointing. We may even want to point at a star for a while and then turn and point in another direction. So these are systems that do not involve the gross guidance—that is, is it going to hit this spot or not—but in what attitude or position does it hit the spot and where we have to control it between launch and impact, it provides the control of the attitude throughout the whole flight.

Mr. McDonough. At the present time, is this theory or has this been proven?

Mr. Wyatt. This is incorporated in the Discoverer vehicle of the Air Force. They have an attitude control package there. We are incorporating it at the present time in a number of our payloads that have not yet been launched.

For example, in an Earth satellite, if you launched it without attitude control, the satellite would always go around the Earth in a fixed position relative to space. It wouldn't point at the Earth, it would tend to look at it from all sides of the spacecraft.

So if we have a device that we want to look at the Earth continuously—let us say a meteorological radar to survey cloud cover, or a system to photograph cloud cover, then we have to force this thing to move in this position so that it is always pointing at the Earth as it moves around. Now, this, as I say, has been done in at least the case of the Discoverer satellite of the Air Force and we are incorporating such packages in some of our own vehicles that require this kind of control. But again, the $200,000 in the line item in the budget is for basic work rather than for a specific system. It is to look at improved methods of getting this kind of attitude stabilization.

Mr. Sisk. In other words, there is no duplication. You are making full use of such instrumentation as the Air Force, the Navy or anyone else has developed?

Mr. Wyatt. Yes, sir.

Mr. Sisk. It is not a matter of your going in and duplicating some of the research?

Mr. Wyatt. No, sir. This is an area in which there are a vast number of unknowns and a vast number of detailed problems. Very fine problems that need to be investigated.

Now, in the rest of the budget we move from this general area of research and development to advance the technology into those sums of money that are going to be applied for specific systems. The first one here is money for the development of guidance and control systems for Centaur boosted spacecraft. The Centaur, as you may recall from the testimony before you, is the Atlas-boosted hydrogen-oxygen second-stage vehicle now under development that will give us a very great increase in capacity as compared with any of the vehicles we have launched to date. It will permit us, as far as our programs are concerned, to launch considerably larger vehicles to the Moon.

It will give us the first opportunity to place what we call a soft landing vehicle on the Moon. We will, with early vehicles, attempt to have impacts ranging from high velocity impacts to impacts where we have spoiled most of the velocity but still hit rather hard. With the Centaur for the first time we will have enough weight carrying capacity to carry the large amount of retro-fuel that we have to fire in order to actually slow the vehicle down so that we can set it rather gently on the surface of the Moon in what we call a soft landing. And this problem of the Lunar soft landing spacecraft embodies all of these elements of injection, midcourse, terminal guidance, and attitude control. They have to all be wrapped up in this one package so we can set it down delicately enough to permit instruments to continue to work on the surface of the Moon. In fact, in some cases to permit us to make remote observations. For example, we may want to land a television camera and have that in working order and scanning and transmitting data back to the Earth.

So we have an item in here for $13 million that is aimed specifically at developing the guidance and control and stabilization systems for these spacecraft that will be boosted with the Centaur vehicle.

Mr. McDonough. Now, let's talk about Centaur for a minute. How far have you progressed on Centaur? The guidance system will be one of the last things that you do. First, you have to have your engine, you have to have your various sections built and you have to prove out the ability of the craft to fly. How far have you progressed on Centaur before you get into the guidance system?

Mr. Horner. The Centaur vehicle will fly first in a little more than a year from now. The problem here, Mr. McDonough, is that any of these developments are rather long-term projects. It takes a matter of years to develop these and if we waited until the Centaur vehicle was completely proven out, a developed item, and then started development of the guidance for the spacecraft that Mr. Wyatt has discussed, it would be many years before we finally had the capability. So even before the Centaur vehicle actually flies we have to begin the developments of these important components for the spacecraft. Indeed we have to begin developing the spacecraft themselves, which are covered in other parts of this buget, in order to have the spacecraft available when the vehicle is available.

Mr. McDonough. You have a $13 million item for Centaur boosted spacecraft for guidance and that includes injection, midcourse, and terminal guidance?

Mr. Wyatt. In this case it does not include the injection guidance.

Mr. McDonough. Midcourse, terminal, and attitude control.

Mr. Wyatt. Yes, sir.

Mr. McDonough. For Centaur, only?

Mr. Wyatt. For the spacecraft——

Mr. McDonough. The spacecraft that Centaur will boost into space?

Mr. Wyatt. Will boost aloft, yes, sir.

Mr. McDonough. Won't you have developed a lot of information on all of these things with the other three items previous to that?

Mr. Wyatt. Sir, the difference is that the other three items are to do research and development on components. To improve air bearings, to improve electronic circuitry. To improve systems to deter-

mine attitude. Here we are talking about putting these together into an actual working system that will be incorporated in the spacecraft and that will fly to and land on the Lunar surface. It is the difference between the—I am trying to find an analogy—research conducted in a wind tunnel on a new airplane, and the actual production of the airplane, itself. Here we are talking about the hardware that has to actually be produced to be incorporated in the spacecraft. The working article.

Mr. McDonough. You have the plastic models and the last one, the working model.

Mr. Wyatt. Not only the working model, but the object we are going to fly with.

Mr. Sisk. If my colleague would yield there, a little bit later, very shortly, we will be discussing the various systems, the various vehicles. We will be discussing Centaur.

Now, in Centaur, you are asking over here a little bit further along, $47 million for Centaur. Now, in other words, in order to get an idea of how much we are putting into each program we would actually have to add some of these figures together. Because, in a sense, the $13 million is a part of Centaur and, of course, the $47 million, in addition, that you are asking for the vehicle itself. I understand the difference, all right, but there we have already added up to $60 million that you intend putting into the Centaur vehicle as such, and possibly maybe there is some other money.

Mr. Wyatt. Sir, if I may, we are referring here—let us go back to some basic terminology. When we say launch vehicle, we mean that booster which puts us on our flight path. When we say spacecraft, we mean that which goes on the flight path. This is the difference between the truck and the load that the truck carries.

Here we are talking about the equipment in the load that the truck carries. When we talk about Centaur we will be talking about—well, we also have to get the truck.

Mr. McDonough. $47 million is the power unit?

Mr. Wyatt. It is the truck. This spacecraft is the object we are going to use the truck to carry.

Mr. McDonough. I don't want to appear critical, but it seems to me that $13 million for the guidance control and attitude control of the spaceship on Centaur—there is only one ship, now——

Mr. Wyatt. No, sir. This covers a number of objects. In other words, we will have several slightly different missions that we will fly with Centaur. I have talked only about the Lunar mission. We will be using the Centaur in 1962, to launch vehicles in the vicinity of both Venus and Mars. There will be spacecraft—actually, two of them, you see. One each. We are then talking about Centaurs for a soft landing on the Moon, and there will be a sequence of those.

We won't make just one flight, we will have to make maybe four or five of those, using essentially similar spacecraft. We will also plan to use the Centaur for what we call rough landings on the Moon prior to this soft landing, in which we do everything except this final retro slowdown. So actually we are talking about money here that will develop and produce guidance and control systems for a number—I would just have to guess and say for perhaps eight or nine articles.

Now, I would not mislead you, however. We are not trying to fully fund these items in any one year, because these are stretched out in delivery, and use time over a period of several years. So that this $13 million will buy a large chunk of what we need, but in 1962 we will probably still have expenses on the specific systems.

Mr. SISK. Now, when do you expect to fire Centaur the first time?

Mr. WYATT. For the purposes we are referring to here, we expect to fire it as a test vehicle—as Mr. Horner said—a little over a year from now. We are expecting to fire it for scientific purposes in the latter part of 1962.

Mr. SISK. I know those have all been given to us——

Mr. WYATT. The planetary dates, for example, the favorable time to shoot at Venus is August 1962, and at Mars is October 1962, in order to require the least energy to get to their orbits.

Mr. MCDONOUGH. For the first firing you wouldn't need this sophisticated guidance control?

Mr. WYATT. Not for the first firing of Centaur. The first several firings will be to check out the vehicle. This is for one where we try to do an honest-to-goodness job with Centaur in space.

Mr. MCDONOUGH. Now, of the $13 million, do you have plans and specifications drawn up on the kind of guidance controls where you could go to your industry and say "This is what we want," or are you still studying this?

Mr. WYATT. We are still studying it. This is a technical function that has been assigned to the Jet Propulsion Laboratory. They are handling the Lunar and planetary phases of our work, and they are doing some of the research and development in their own facilities. They are also preparing the specifications for the systems which we will then purchase on the outside.

Mr. MCDONOUGH. Do you think that the $13 million would provide the preliminary study and the final purchase of materials?

Mr. WYATT. Well, both. I wouldn't say final. It will provide the preliminary study and begin the purchase of equipment that we intend to buy.

Mr. WILCOVE. What kind of a shot do you plan for August 1962?

Mr. WYATT. A near miss of Venus. We will attempt to get within a relatively few thousand miles. We will include scientific instrumentation that will not only give us what we call a sweep out of data, from here to Venus, say, field measurements of energetic particles, magnet fields, and that sort of thing, but also equipment that will, when we get near Venus, allow us to make some better analysis of the atmosphere. Possibly of the ionosphere. The same general class of measurements that we are doing with our own satellites in the vicinity of the Earth.

In other words, we think now of what we call geophysical phenomena, those phenomena that are affected by the earth. We will be trying to measure the Venus affected phenomena, but not in extremely close proximity. We would not anticipate that we will get into very, very close proximity, but within several score of thousands of miles.

Mr. WILCOVE. The shot will then go around the sun?

Mr. WYATT. It will go out into some sort of permanent trajectory around the Sun.

Mr. WILCOVE. I have heard reports that the Russians are prepared to try an orbiting of Venus in August, with sufficient instrumentation to scan the surface. Have you heard anything about that?

Mr. WYATT. No, sir; I have not.

Mr. WILCOVE. You also have a Venus shot planned for some time this year, do you not?

Mr. WYATT. No, sir. That shot will take us in to the orbital distance of Venus, but in order to hit Venus we would have had to fire last June. The shot we propose this year will carry us in toward the Sun and will go in as far as the orbital path that Venus has, but Venus won't be there. Venus will be approximately around on the other side of its trajectory. It is a misnomer to call this a Venus shot. It is a shot in toward the Sun to the distance of Venus from the Sun.

Mr. WILCOVE. What do you hope to accomplish by that?

Mr. WYATT. Principally two things. Again, this so-called sweep-out of data from the Earth to that distance, of some of the basic physical phenomena of space. One of the most important things, however, is going to be an evaluation of the communications system for returning these data from these distances.

In other words, we are just not certain how far we can actually maintain effective radio contact and obtain intelligible radio information.

Mr. MCDONOUGH. How many miles from the Earth to the orbit of Venus?

Mr. WYATT. I think the minimum distance is some 26 million miles. Actually, the path that it flies, if I recall correctly, is closer to 120 million miles, because you start and you fly around this way instead of going straight in.

Mr. MCDONOUGH. But to come within the orbit it is 26 million miles?

Mr. WYATT. Twenty-six million miles if you fired directly in toward the Sun. This would require exorbitant energy to kill all the Earth's velocity and head in toward the Sun. We use the Earth's velocity and actually slow down a little bit, and fall into the direction of the Sun. We fall into a parabolic path like this [indicating]. It gradually gets us closed to the Sun.

The actual flight path then is up in the hundreds of millions of miles. I am not sure of the exact figure—the distance we actually have to transmit data. This is one of our major considerations here. It is simply an evaluation of the data transmission system.

Not only of the transmitter, and the spacecraft, but of our own receiving system on the ground.

Mr. WILCOVE. When do you plan to make the shot?

Mr. HORNER. During the current quarter.

Mr. WILCOVE. I have already read in various periodicals and papers that it will take place some time in February.

Mr. HORNER. That is wrong. It will be during the month of March if we go according to plan.

Mr. WILCOVE. Do you have a specifice date in mind?

Mr. HORNER. We have planning dates, but would rather not give those in open session because they create real problems for our operation.

Mr. WYATT. We could give you the specific date, however, if you request it.

Mr. HINES. Your recent developments of guidance control for spacecraft, would be applied to Centaur and Saturn. What are the essential differences?

Mr. WYATT. The differences are in the accuracy of the unit you can carry because of the weight involved.

When we get to Saturn, we will have so much more weight capacity that we will be able to carry actually better midcourse and terminal guidance systems. We have not, so far, been able to incorporate any but the very simplest kind of midcourse guidance.

When we get to the Centaur class we will be able to incorporate rather respectable systems, but still we find if we can add little more weight we can make a better system. Principally, when we get to Saturn we will go rather all out into a really refined system.

Mr. HINES. Then it will be a continuous development. One single line of the development?

Mr. WYATT. Well, a single line of development, but with offshoots into specific products.

Mr. HINES. The point I am getting at is they don't become separate distinct entities far back in the early days?

Mr. WYATT. No, sir. They are related. The whole art develops, and then at a given time we will do the best we can with the payload we can put up, but as we go on we can do better, and so with time we gradually will improve these systems.

Mr. HINES. And the funding will reflect that?

Mr. WYATT. The funding will reflect that.

The reason the funding is relatively lower here on the systems for the Saturn booster spacecraft is that the availability time of the Saturn itself is further downstream and, hence, we have more lead-time available to it.

Mr. HINES. This is what sponsors this question, a difference in funding here.

Mr. WYATT. We have more leadtime on the Saturn than the Centaur. We must get started rather heavily on the Centaur program.

Mr. SISK. On the last couple of items there, on the development of guidance control on the Saturn boosted spacecraft, that, of course, is going to be a continuing thing for several years. Actually, right on through until the ultimate complete of the program.

Mr. WYATT. Yes, sir.

Mr. SISK. Let me ask you this. Do you feel that the amount of money represented here is sufficient, the $1,650,000; has that figure been changed at all from your original request?

Mr. WYATT. I don't recall offhand the original detailed request here, on a line-item basis.

Mr. HORNER. There has been no change in these items during the budget——

Mr. SISK. These are the figures that in your best estimate will do the job for fiscal 1961?

Mr. WYATT. Yes, Mr. Sisk, as I pointed out, the Saturn figure is lower than the Centaur figure because we have more leadtime before we have to have the Saturn system.

Mr. SISK. I understood that. I realized the reasons why, of course, it wouldn't be nearly as much because it is more or less just starting.

whereas we are going to need for 1962, as I understand, these packages for Centaur.

Mr. WYATT. Yes.

Mr. MCDONOUGH. Isn't it also possible that the knowledge you gain from the development of the guidance and control system for Centaur may be applicable to Saturn without the full expenditure of the $1,650,000? Won't you learn——

Mr. WYATT. Again, we are hoping to buy flight hardware with the $13 million of Centaur money. Now, the technology we fly there will certainly be applicable to the later Saturn systems. And as such we will not have to beat over all of the same ground.

However, the Saturn system will be essentially different, sizewise, and have a different capability. I would not say we could perhaps avoid spending this $1,650,000.

Mr. SISK. On the last item you have there, advanced technical developments, components, and materials, you apparently just tossed in several items.

Mr. WYATT. This is a bit of a catchall section. This actually represents the vehicle engineering system and the advance technical developments components and materials section, that is for inhouse work at the Jet Propulsion Laboratory. They are doing a wealth of basic reseach and development, and we have grouped together a number of those items into these two categories for the $3 million.

Mr. SISK. The total for this more or less advanced technical program here is $21,200,000.

Before we leave this, are there any questions that either the staff or members have on these items?

The Chair would suggest that what we will do is go over these, proceed along and attempt each day to go into executive session to finally pass or approve these.

If there are no further question—Mr. Wilcove.

Mr. WILCOVE. Mr. Horner, with regard to the specific dates—I think you referred to a Venus probe, did you not?

Mr. HORNER. It has been referred to as a probe to the Venus orbit.

Mr. WILCOVE. With regard to the specific date, is that classified?

Mr. HORNER. No, sir; it is not classified. The reason we hestitate to put that out in open session is that it tends to be picked up immediately by the press, it becomes a fixed date then, and it raises, by a variable amount, the pressures that are brought to bear on development teams to meet that date, and we are afraid that by bringing those pressures to bear there might be a tendency to fire, even if something goes wrong in the last few hours of preparation, which would indicate that we ought to delay it a day or so, to be sure that the vehicle is right.

We have a very considerable investment in each one of these shots, and we feel that the last decision for making the firing should be based upon the technical integrity of the vehicle at the time, and in no way be influenced by our pressures of public posture at that moment.

Mr. WILCOVE. I am not going to press you to reveal a date, but you do know, of course, of the access-to-information provision of the Space Act under which you operate?

Mr. HORNER. We are very conscious of that, yes. I just wanted to explain our policy.

If the committee feels strongly that we should change that policy, we would be glad to discuss it more in detail and accede to the wishes of the committee.

We think it would be a wrong thing to do.

Mr. SISK. We can appreciate your problems. I am inclined to agree basically with the problems that would be created by saying that at 12 o'clock, high noon, on March 5, we are going to fire.

I think, of course, on these shots that it might be advisable, where you could give the information, to simply say—and this is merely only my suggestion, and maybe this isn't practical, either—but to simply say we hope in the first, second, or third week in March, everything being OK, to fire a shot.

I think, actually, to be completely factual, that although you may be aiming at a target date it is pretty impractical to say a month ahead on any of these vehicles that you are going to fire it at exactly a certain time; isn't it?

I mean to pin it down?

Mr. HORNER. That is very true, Mr. Chairman. Perhaps it is worth explaining for just a minute, what our policy is in this regard, in some detail. Because I would like to have an understanding of it.

We feel that we can reveal our planned shots for the ensuing 18 months, on a quarter by quarter schedule. And you will recall that in our earlier discussions before the full committee in open session we did show what our schedule was, on a quarterly basis, during that time period.

Beyond that we have shown our planned shots by years. Eighteen months from now we are scheduling our shots by years.

Now, obviously, we have to, for our own operations, plan on a finer grain scheduling than those kinds of time periods, but as long as we have that information held within official circles we then exercise the freedom of adjusting those dates to fit the technical integrity of the shot as it comes out.

Now, as the individual shots actually approach, again being conscious of the requirements under the National Space Act of 1958, to make full public disclosure of information, we are conscious of the problem of the public media. We do advise the press media, the radio, television, a week in advance, on a hold for launch release basis, so they are able to prepare for proper coverage of that.

This procedure has worked very well thus far, and we feel there is real advantage in relieving our technical project people from the pressures of meeting a scheduled time and date, that has to be set some months in advance in order that all of the preparations are ready at the same time.

Mr. SISK. I think that is a good explanation and I am inclined to agree. You get into problems when you start setting too accurate dates.

Of course, I think it is well to keep the public informed as much as possible and I think you certainly indicate in your statement you agree with that, as the shots proceed along.

Mr. RIEHLMAN. Could I ask just one question. On the last item that requires $2 million; the one on advanced technical developments, components and materials.

Could you give us a short explanation of what that might be comprised of?

Mr. WYATT. Yes, sir.

This is a compilation, actually, of a number of fairly small projects that are conducted inhouse at the Jet Propulsion Laboratory, on a research and development basis. We have undertaken, in the interests of keeping the Jet Propulsion Laboratory at the finest technical pitch possible, to more or less, shall, we say, underwrite a certain level of effort in self-generated research and development.

In other words, the people at the Laboratory say "Here is a problem which I think needs looking into." These areas referred to here are simply a compilation of a number of things where they look at this component as they work along with it, and they say "I would like to do some more work; I am not quite pleased with that," or "Here is a material that we are using. I am not quite satisfied that the best material is being used, I want to do a little experimenting with it."

Mr. RIEHLMAN. You just can't point to something specific. It is a general term, and you just cannot—it is more or less a guess as to what you are going to do, but you need funds for it.

Mr. WYATT. It amounts to a level of effort. We think a balanced program requires a certain level of this kind of work, at your own volition, and at your own instigation.

Mr. HINES. It gives you tolerances of operation, in other words?

Mr. WYATT. Yes.

Mr. SISK. Are there any other questions before we leave this portion of the program?

I might say to my colleague from New York, it was my thought that what we would do is pretty well discuss these and then proceed on with the witnesses. Then, possibly, before we actually approve these items, take them up in executive session, if you would like.

I am not too concerned but what we could do it in open session, but I thought at least here in the initial phases we will go ahead and let the witnesses discuss these others. Then we can actually go back and approve these items.

SOLID ROCKETS

Mr. SISK. Do you wish to just make a brief comment on this?

I would like to have your comment with reference to the decrease because in fiscal 1960 you had $3,785,000. You are only asking for $2.8 million in 1961. Now, just briefly explain the reason for the reduction in request there.

Mr. HORNER. It is a reduction in effort based upon the program needs. There are certain specific tasks in the solid-propellent area. Most of this work is being carried out by the solid-propellent group at the Jet Propulsion Laboratory, and this reflects partial solutions—advancement toward solution of some of the problems that they have tackled, while there is still very substantial work going on in other areas.

The kind of problems they are working on are research and development necessary to producing motors with very low chamber pressures, for example. These are most applicable to last stages, to terminal-guidance propulsion, because you need relatively lower burning pressures, chamber pressures, in the hard vacuum of space.

They are working on improving fabrication techniques of the rocket cases so that a larger fraction of the total weight can be propellent because this is the fraction that provides the energy which is the purpose of the rocket in the first place, of course.

They are also working on techniques for steering solid-propellant rockets. One of the major deficiencies of a solid-propellant rocket is its incapability to be vectored as a whole, like a liquid-rocket engine can be. The techniques that are used of vectoring just the nozzles, of providing auxiliary gas jets to steer the nozzle, or in some of the older systems of actually putting vanes in the jet exhaust, are being studied.

There is also a need for development work in the area of cutting off the propulsion, of modulating the thrust of a solid-propellant rocket. Where a liquid-propellant rocket can be throttled, like an internal combustion engine, for example, simply by reducing the flow of propellants, this is not possible with a solid-propellant rocket, and this is desirable from the point of view of applying a finite amount of thrust to give just exactly the right impulse for midcourse, or terminal guidance.

Then a specific application of this type of thrust modulation, of course, is very fine control of thrust cutoff as it finishes burning. These are the kinds of problems that are being worked on. The reduction in level of effort reflects progress toward objectives in these areas.

Mr. SISK. I appreciate that explanation. Of course, the question I had in mind, as I glanced over these figures the other day, was the fact that once we get out into outer space, if I have understood a lot of the testimony we have heard, there are certainly very definite advantages to solid-propellant fuel if we can technically handle it. There are many problems. However, it is storable and can be carried for long distances, and you don't have the problems of temperature.

Now, in reading over this NASA budget summary here a day or so ago—do you feel there are any insolvable problems in this area? This is what I was somewhat concerned about in this reduction of money here, namely whether NASA had in mind, let's say, to some extent dropping, at least for the time being, solid propellants, and their use in some of the vehicles, and going more to the hydrogen vehicles. I was just a little bit concerned about it.

I just wanted to make sure that this did not indicate a lessening of the effort in the solid-propellant-fuel program.

Mr. HORNER. It certainly does not indicate, Mr. Sisk, any attempt on our part to abandon solid propellants in some of their desirable applications. We must recognize, however, that this is an area where there is substantial work going on in the Department of Defense. We have a very closely coordinated program with the Department of Defense.

For example, at the present time we have an agreement that substantially all of the work in very big solid-propellant motors—what we call big grain solid-propellant motors—is being carried on in the Department of Defense. So in a sense you might say that this reduction in our level of effort as it is reflected by the funding is influenced by the fact of the increase in the amount of work going on in the Department of Defense, but we sort of recognize this is a joint program.

Mr. SISK. I appreciate that. Of course, on the work that is going on now on Minuteman, the solid-propellant rocket, you have full

liaison. NASA will be fully acquainted with every breakthrough and all technical research material as it is developed in the Department of Defense on the Minuteman program. Is that right, now?

Mr. HORNER. We have a very closely coordinated program. We visit the industrial contractors working on Department of Defense programs—as a matter of fact, I personally was out to visit Thiokol, who is one of the major contractors in the Minuteman program, only 3 weeks ago. I think we have completely satisfactory liaison with the Department of Defense in this area.

Now, I point out that this reduction of about $1 million in our solid propellent expenditures does not indicate a reduction in the number of our scientists who are actually working in this area. There is a substantial part of this money that goes for the procurement of hardware for research and development purposes.

One of the very important aspects of a development program in solid propellants is the actual firing of test rockets.

As a specific research program progresses there comes a time when it is necessary to do actual experimental firings. This reduction in funding in this particular year reflects a requirement for less of this kind of hardware purchase during this year.

Mr. MCDONOUGH. I have no questions.

Mr. RIEHLMAN. I have no questions.

Mr. WILCOVE. I understand the President gave your agency jurisdiction over superboosters. Is that correct?

Mr. HORNER. Yes, sir; we do have responsibility for the development of superboosters.

Mr. WILCOVE. You have a booster of 1- to 2-million-pound thrust that would be considered in that category?

Mr. HORNER. Most definitely; yes, sir.

Mr. WILCOVE. The Air Force apparently initiated plans looking to the development of a solid-propellant booster of 1- to 2-million-pound thrust. How do you account for that?

Mr. HORNER. I would like to discriminate between words here. It is my understanding, and I am almost certain that this is the case, that the Air Force program is not, in fact, pointed toward the development of a booster. It is pointed toward fundamental work in research of solid grain propellants, and big grains. They are at the present time considering a contract which had been coordinated with us, and which we very heartily endorse, for the development of a solid-propellent grain size which will produce, I believe, 20 million pound-seconds of total impulse.

Now, this could be used, for example, in a rocket motor to produce a million pounds of thrust for 20 seconds. It has not anywhere near approached that stage of development at this time, and it will be a matter of years before it does.

I would also point out that it could be used for a 250,000-pound thrust for 80 seconds. So in that sense there is that degree of latitude. This is one of the very attractive aspects of solid propellants, incidentally. You can have a wide range of combinations of maximum thrust and controlled duration.

Mr. WILCOVE. From all I have heard, the Air Force hasn't gone too far, but they apparently look toward a booster that could have a 1- or 2-million-pound thrust.

Mr. HORNER. I am sorry. I did not make myself clear. It is not a booster in the sense of being a vehicle that will lift a space vehicle. It is only a solid grain motor of a total impulse of this size, and it could have the capability of producing a million-pound thrust for 20 seconds. But obviously that is of no use in a space program. A 20-second motor wouldn't lift a vehicle out of the atmosphere. It wouldn't be useful for that purpose. This is an experimental development program.

Mr. WILCOVE. Then what use would the Air Force have for this?

Mr. HORNER. If they used this particular grain size I would suspect it would be on the order of 250,000-pound thrust engine for 80 seconds, which is the size they are currently working toward.

Mr. WILCOVE. The rumors in the industry, though, seem to be that they are aiming for a motor of 1- to 2-million-pound thrust.

Mr. HORNER. I can understand how the rumor is generated because, as I mentioned, the motor can have a million-pound thrust for 20 seconds. This, as I said, is one of the flexibilities in solid propellant.

Mr. WILCOVE. If they carried through further on that, if they went into a feasibility study on the development of a motor of one to two million-pound thrust, would you feel that would be taking away some of your jurisdiction under the President's orders?

Mr. HORNER. We haven't approached that problem yet. Certainly if they were to develop a motor four times the size of the one that I understand they are looking at at the moment that had a total of impulse of 80-million-pound seconds—in other words, had a capability of producing a million pounds of thrust for 80 seconds, and assuming that that was feasible, which we are not certain of yet, then we would definitely be interested in that, and we would determine as to whether or not that should be a development under our cognizance or under the cognizance of the Department of Defense.

I think again this would depend upon proposed uses of it.

Mr. WILCOVE. What would be your definition of a superbooster?

Mr. HORNER. I don't think there has been a finite definition. It has generally been accepted that a booster with a rocket engine producing a thrust of a million pounds or over is in the category of the superbooster. Now, I don't know that that is a firm cutoff. I am not saying that a 900,000-pound engine isn't the superbooster. We just don't have any of that size.

The term "superbooster" has been used to speak of Saturn and the Nova type vehicles.

Mr. SISK. Are there any further questions on solid propellants?

By the way, while I think of it, there is one further question I wanted to ask, particularly with reference to the $13 million item in this program for the Centaur package there.

Have any contracts been let with firms anywhere at the present time on that program? Do you have any outstanding contracts?

Mr. HORNER. On the $13 million, Mr. Sisk?

Mr. SISK. Yes.

Mr. HORNER. There have been no contracts—well, there may have been some small supplier contracts let by the Jet Propulsion Laboratory to provide components for their material development.

Mr. HYATT. Probably components. This is a fiscal year 1961 initiation, and first we have to catch the rabbit.

Mr. SISK. Actually, there would be no contracts as of the present time—none have been let?

Mr. HORNER. Not in that $13 million. There may have been in the component areas which are on the first three lines there, I believe, which will feed into that area ultimately.

LIQUID ROCKETS

Mr. SISK. Now, we will move into liquid rockets. Here we are confronted with a request of $63 million as against $30 million last year, which means we are dealing with a rather substantial sum of money, so I would like some comments on your justification on that, in addition to what we have here in the printed form.

Mr. HORNER. Mr. Hyatt will discuss this section of the program, Mr. Sisk.

Mr. SISK. All right, Mr. Hyatt, go right ahead.

STATEMENT OF ABRAHAM HYATT, DEPUTY DIRECTOR, LAUNCH VEHICLE PROGRAMS

Mr. HYATT. The liquid rocket engine program, of course, is our mainstay at the present time in the space program.

Of the total of $63 million, about two-thirds goes into the big million-and-a-half-pound thrust engine. Another fourth goes into the development of a 200,000-pound liquid oxygen, liquid hydrogen, engine which eventually will power one of the stages of the Saturn vehicle.

The rest of it, some $5½ million, is used for an innumerable number of items that we would have to work on, in the development of liquid engines. We have problems such as burning propellants stably in rocket engines.

Rather than conduct the experimental testing and development with full size engines, it is frequently possible to learn much of the phenomena of combustion with scale models. They are much less expensive to construct and to test. For example, in one case, to study combustion oscillations, a two-dimensional model was constructed with transparent sides. By such means the burning process in the chamber could be photographed and carefully studied. It is this kind of work for which the additional funds are needed.

Another area of effort is the early applied research and experimentation to develop engines using storable propellants. Such engines will eventually be needed for changing direction in space flight, for slowing down to land on the moon and for escaping from the moon. It is true that at this time such engines are not needed, but much time is required to develop and perfect them. They are among the longest leadtime items. If we are to have them at the same time that we will have launching vehicles capable of putting sufficiently large load into space to need the engines, then it is necessary to start and carry on the development now. The funds asked for are just enough to carry on the work at an efficient and ecomonic level.

Mr. SISK. Now, this $41 million. Let us discuss that one item for a moment.

How much of that $41 million is going to North American, or its Rocketdyne Division, under existing contracts?

Mr. HYATT. All of it, with the exception of fuels. We provide fuels. The total of fuel on there—I could make a guess, but I would rather furnish the number if that is desired.

Mr. SISK. Make a guess. You mean with reference to——

Mr. HYATT. I would say about $5 million of that would be for fuel. Liquid oxygen, liquid nitrogen, ordinary jet propulsion kerosene fuel, etc.

Mr. SISK. How much money has gone to Rocketdyne so far?

Mr. HYATT. Ten million dollars in fiscal 1959. Twenty-three million dollars in fiscal 1960 ($1.2 of the $24.2 shown was for fuel). If you subtract $1.2 for fuel, it is $23 plus $10 or $33 million.

Mr. SISK. The original contract with Rocketdyne was for approximately $102 million. Is that right?

Mr. HYATT. That is right.

Mr. SISK. This $41 million is just a part of that contract. Is that right?

Mr. HYATT. That is right.

Mr. HORNER. Mr. Sisk, it is necessary to note that actually that $102-million contract has been amended to be $105, now. It is necessary to note that called for a specific statement of so much work on this engine development.

It is undoubtedly true that if we are to use this engine in a vehicle, that statement of work will have to be still further amplified to produce a reliable engine adapted to a specific vehicle, and that will be in later year funding.

Mr. SISK. Of course, that is the thing I was going to get into a little bit later. I want to yield here to my colleagues in case they have some questions. I don't want to dominate the questioning.

I am concerned, of course, because we discussed last year in these same hearings, as my colleagues will remember, just what we were going into. I realize that some of these questions are impossible for you people to answer because you don't know all the complexities and problems you are going to run into. But we talked about the $102 million—as you say, now, I believe, $105 million. In all probability, this is only the first phase on this 1.5-million-pound thrust engine.

I do think this is something that our committee, being responsible, is going to have to watch. I think you will agree with me that we want to watch this rather carefully and try to be as sure as possible that everything is being done that can be done to conserve dollars and still get ahead as rapidly as we can on this program. I would hope that we will be given as much information as possible as we add to that particular contract.

Mr. MCDONOUGH. I have no questions.

Mr. SISK. Mr. Riehlman.

Mr. RIEHLMAN. I have no questions, Mr. Chairman.

Mr. SISK. Now, how much of this money in this list here is involved in the Saturn program? What portion of this, with reference to liquid rocket fuels, is concerned with the Saturn program?

I believe the budget calls for $134 million for Saturn. How much of this is involved in the Saturn?

Mr. HYATT. The portion of this program that will eventually go to Saturn is the $16 million for the large hydrogen-oxygen engine.

Mr. SISK. That is an upper stage?

Mr. HYATT. A second stage. And possibly a third stage, also. No money for this engine is carried in any other place in our budget. All of the rest of the money carried under the Saturn program is for the Saturn vehicle itself.

Mr. SISK. Going back to this 1.5-million-pound trust, and this $41 million that is involved here, how much other money is included in this research and development budget for this 1.5-million-pound-thrust engine?

Mr. HYATT. No other money in research and development.

Mr. SISK. This is the entire amount in the research and development budget for this program?

Mr. HYATT. Yes, sir.

Mr. SISK. How far along has North American gone in its development? How much money has been expended so far as of the moment?

Mr. HYATT. We can supply that.

(The information requested is as follows:)

As of January 31, 1960, Rocketdyne has recorded costs of $13,992,439 and has a total of recorded costs plus uninvoiced commitments of $19,188,493. The presently assigned total funds in the contract are $33 million which are estimated to cover costs until August 30, 1960.

Mr. MCDONOUGH. It is presumed here that funds for 1959 and 1960 have been expended, and you are asking for $41 million for 1961.

Mr. HORNER. They are currently on their obligation rate. They are currently obligating money at the rate of $2 million a month, which is indicated in the fiscal year 1960 appropriation. That means that of the current year's money there is still about nine—something like $9 million, or $10 million, left to be obligated during the current fiscal year.

Now, of course, a lot of that money has not been actually spent, and it won't be spent until the actual hardware items have been produced, or work has actually been done.

Mr. MCDONOUGH. I am interested in the chairman's question from this point of view, also. This is a one million-and-a-half-pound-thrust rocket engine, isn't it?

Mr. HORNER. Yes, sir.

Mr. MCDONOUGH. And the money that has been spent up to the present time, has that been spent in research and development or hardware? Have you built any part of the million and a half——

Mr. HORNER. It has had considerable development work actually done on the engine. The thrust chamber has been developed and fired. They have fired it enough so that they are fairly well assured of stable burning, that the burning is steady and will not oscillate to explosion. There has been considerable work done on the regenerative cooling of the nozzle and chamber. They are currently fabricating a test engine which will be tested at the Edwards Rocket Engine Test Station.

Mr. MCDONOUGH. That is a captive test?

Mr. HORNER. A captive test; yes, sir.

I would remind you that this is only an engine development. There is no money in this for a vehicle development at this time. Some of the money we were discussing earlier in vehicle technology that Mr. Wyatt spoke to is being used for studies as to how best to fabricate vehicles of this size to be used ultimately with this engine.

Mr. McDonough. You have no precedence to go on here, do you? You are experimenting all the way here, aren't you?

Mr. Horner. That is exactly right, in terms of any vehicle of this size. The nearest rocket engine of this size has been under development at Rocketdyne, the same people who are developing this engine, at a size level of about 400,000 pounds, so it is a size about one-fourth the size of this engine, and it is a scaling up process.

Mr. McDonough. They have developed that, themselves?

Mr. Horner. They developed it under the sponsorship of the Department of Defense.

Mr. McDonough. That has never been used to fire a spaceship?

Mr. Horner. There has never been a vehicle built around that engine; no, sir.

Mr. McDonough. And the work that has been done is on the first chamber, the single chamber of 1½ million pounds thrust?

Mr. Horner. Yes. Well, there have been a few chambers fabricated in the experimental program. Part of this process is inevitably a cut-and-try process. The science of designing combustion chambers is not an exact science. You design them to the best theory that is available, and then go out on the test stands and try them. You frequently find when you try them that although the theory says you will have stable combustion you in fact do not have stable combustion, and then you change some of the physical parameters such as the length to diameter ratio of the combustion chamber, or the characteristics of the fuel injection plate, and you just try until you get a proper combination that works well.

In 15 years of rocket engine development this is still necessary. It is particularly necessary in this because, as I mentioned, there is no precedent for this size.

Mr. McDonough. Is the principle involved here the same as the principle in a jet propulsion airplane engine?

Mr. Horner. Some of the principles of thermodynamics are certainly the same, and applicable to both technologies. The major difference, Mr. McDonough, is in the rocket engine the oxygen is also provided, whereas in the turbojet the oxygen is taken out of the atmosphere that is drawn through the engine.

Mr. McDonough. And, of course, the volume and the expulsion is much greater in this engine than it is in the other?

Mr. Horner. This is almost purely a function of the rate of propellant consumption. The propellants are consumed much more rapidly than they are in a turbojet engine.

Mr. Hyatt. Also the temperatures.

Mr. Horner. Of course, for comparable size thrust, the flows are comparable.

Mr. McDonough. You are escaping gravity at a right angle where the other way you are escaping gravity at another angle.

Mr. Horner. There is a real influence, as far as a space vehicle is concerned, on the difference in gravity losses, depending on exit angles.

Mr. Sisk. Now, let us go back to the schedule on the 1.5-million-pound-thrust engine. This is after all, I think, one of the most important features of NASA's work in the future, because this apparently is going to have to be the vehicle which we hope will become the workhorse in space, or will be the foundation of that workhorse, is it not?

Even though we think of Saturn today as supplying the propulsion that we are going to be dependent on for the immediate future, yet, looking ahead some years—and I am thinking now of 1968 and 1970—this program actually is fundamental and basic to your whole effort, isn't it?

Mr. HORNER. Yes, sir.

Let me illustrate that by an example. One of the objectives which we see down the road in our space program, not in the current decade, but perhaps in the next one, is the landing of a man on the Moon. In order to do that, the propulsion energy that is required is of such magnitude that if such a mission could be carried out with a direct ascent from the Earth, using liquid chemical propulsion systems, an engine of this size appears to be necessary.

As a matter of fact, it appears that we will have to use numbers of these engines grouped together to produce a total thrust of between 5 million and 10 million pounds for launching the first stage from the ground in order to produce a sufficient payload at the Moon that we will have propulsion available there to return to Earth.

Now, there are other possibilities, other possible ways of accomplishing this mission. Two of them that I might mention just very quickly is the possibility of using a Saturn-size vehicle, and doing orbital refueling. In other words, having several smaller vehicles rendezvous in an orbit with the Earth, refueled in this orbit, and then start from there toward the Moon, which will take less energy from that position.

Another possibility, of course, is using a nuclear rocket.

Now, there are various risks, different development tasks and different advantages and disadvantages to each of these systems, but recognizing that this is perhaps the most straightforward system based upon this particular engine, we feel that it is essential at this time to go ahead with the development of this engine, though we have not at this time started the development of the vehicle portion.

Mr. SISK. Do you feel the F–1 engine project is on schedule? Are you satisfied with the way it is proceeding? I am referring to the work Rocketdyne is doing and the whole program on the 1.5-million-pound engine?

Mr. HORNER. It is not on the schedule it was originally contracted for. It was originally contracted, I believe in January 1959, on a schedule to produce a qualification of the engine by actual test experience on a static test stand in a period of time of 3½ years. We recognized from the beginning that there had to be some flexibility—perhaps 3½ to 4 years. Forty-two to forty-eight months.

However, during the past year we have had to stretch out that schedule because of a shortage of resources. We have established a new schedule of perhaps a year to 18 months longer than the original schedule, and based on that schedule this new sum of money is proper support for the engine.

The reason more money is required this year than was required last year is because of the changing status of the program as it proceeds down the development path. As we get more of the design work done we have done more of the experimental fabrication, and we know how to make parts. We then must go into this phase of the develop-

ment program which requires large numbers of tests to develop and demonstrate the reliability of the individual components.

It is this part of the program of making repeated rocket engine runs, using up large amounts of propellants, and using up the actual hardware, that becomes quite expensive, this is why we have had to go from $24 million during the current fiscal year to $41 million during the next fiscal year.

Mr. SISK. Now, how much have we stretched out beyond the so-called 42 to 48 months? What is now the schedule?

Mr. HORNER. It is approximately another year.

Mr. SISK. In other words, we have gone up to probably 60 months. Is that right?

Mr. HORNER. Yes, sir; total time.

Mr. SISK. You said here "because of a shortage of resources." Now, what are you talking about? You say this has been brought about by "a shortage of resources." I believe I am quoting you.

Mr. HORNER. Yes, sir.

Last summer we had to make an accommodation to our program, as you will recall, as a result of lower appropriations than authorization. This was in the amount of about $30 million, and we had to find that money in the program that we had planned at that time on the schedule that we had planned, from those elements in the program where the money could be made available.

This particular engine was at a stage of development at that time where it was one of the few places that we could get this kind of accommodation, and the money in this particular program was reduced by a little more than $6 million. And at that time we had to reconstitute the schedule.

Mr. SISK. Well, I recall very well the fact because I had to take the floor on this particular issue when the Appropriations Committee reduced it about $30 million.

Mr. WYATT. I believe it was $34 million.

Mr. HORNER. It is just $29,725,000.

Mr. SISK. Some of us were somewhat concerned about that at the time.

In answer to questions on the floor at the time this incident occurred, Congressman Thomas of Texas, who was, as I recall, handling the bill—I may be wrong there, I believe that is right—indicated they wanted to see this program proceed, that there was no intent on the part of the Appropriations Committee to slow down work and that if the moneys appropriated were not sufficient to meet the schedule and demands, at your request they would take care of the situation.

When did you first make an additional request? When did you make a request for supplemental funds to offset this problem?

Mr. HORNER. Mr. Sisk, this kind of a procedure is not possible in a development program of this nature. We were at a very sensitive time in the program when many of the components were actually under design, where the prime contractor was going out on subcontracts and making commitments and neither could he legally authorize his subcontractors to obligate funds nor could we authorize him to obligate his people to resources we did not have legally available to ourselves.

The program was in such a status, and I believe the Congress was so advised by the Administration at that time, that we needed the money

available at that time, in July of 1959. Not getting the money, we had to reschedule the program. We really had no choice.

Mr. SISK. I appreciate your answer. I hope you understand, Mr. Horner, there is no criticism on my part implied at all in this situation, but I think what we desire to do here is to make a record as clear and concise as possible and to indicate this has happened because of a failure to make this total appropriation. We are going to have to go to the floor very shortly and justify every dime in this budget and at the same time if we, who have the responsibility of authorizing it, feel that the money is necessary, then we are going to have to be in a position to say to the Appropriations Committee that it is imperative this money be made available.

Therefore, I think it is well to establish for the record—and there is nothing political in this one way or the other—that a lack of appropriations might tend to slow down a program. That is why I think this is of some interest here. I am somewhat concerned now. It would seem to me, then, that what we have actually done here is delayed the progress and the ultimate completion of a large size engine by a year to a year and a half or maybe 2 years. Is that generally true?

Mr. HORNER. Yes, sir.

Mr. SISK. And you say that is specifically due, not to any delay on the part of North American or Rocketdyne or anyone else but due to the fact that you did not have the money available last July 1——

Mr. HORNER. That is clearly the case, Mr. Chairman.

Mr. SISK. To make the commitments.

Mr. HORNER. Yes, sir.

Mr. RIEHLMAN. It was a lack of something like $6 million. Am I correct in that?

Mr. HORNER. The total budget—I almost used the term deficit but it isn't a deficit until we have it and we didn't have it.

The total difference between the authorization upon which we had originally based our program planning and upon which the schedule for this particular engine development was based, the difference between this authorization and the appropriation was about $30 million. I think it was $30 million and a few hundred thousand.

Mr. RIEHLMAN. That is the overall reduction?

Mr. HORNER. In our total program.

We had to go to our program and find ways of saving from our planned obligation rate, this $30 million. The only places we could save this, and do the least damage to our programs—one place was in this large engine and we found it necessary to reduce this by something over $6 million.

Mr. RIEHLMAN. And that reduction of $6 million has retarded the program as much as 12 months?

Mr. HORNER. Yes, sir. Now, this might seem out of proportion, but it is a function entirely of where in the program this kind of reduction occurs. And as I mentioned, this particular development program was rather sensitive to a reduction at this time because it was in the design stage and it was in the configuration formulation stage and many things just had to be delayed because of the lack of

this $6 million. Having delayed this, puts off the whole test program and the test program procedures.

Mr. RIEHLMAN. Well, right now the appropriations committee has under consideration a supplemental. Are funds included in that supplemental to step up this program?

Mr. HORNER. No sir, they are not because it was clear to us that we could not have supplemental appropriations available until sometime during this half of the current calendar year. It doesn't make good development sense to carry a program along at a level of, for example, $2 million a month, and then make a sharp increase. We have to make a consistent programing increase because in the final analysis, this is a function of the people you bring to work on this program.

So we had no choice but to reschedule the program at this time, and this is really the reason why we actually lost more time than would seem to be commensurate with the proportional reduction of funds.

I am afraid I haven't made this very clear but let me try it this way: If we had asked for a return of that money in the supplemental it couldn't actually be applied to the program very much ahead of the fiscal year 1961 appropriation anyway.

Mr. RIEHLMAN. Is that because of the programing?

Mr. HORNER. It was partly, Mr. Riehlman, because of our assessment that the earliest we would likely get a supplemental appropriation would be in March or later of this year anyway and there is a matter of a very few months difference between the availability of a supplemental appropriation and a 1961 appropriation.

Mr. RIEHLMAN. And nothing could be done in a constructive way to really speed up the program. Even if you had the funds available in March.

Mr. HORNER. I wouldn't say that nothing could be done but anything we did do would not be as effective a use of our resources. It would be an inefficient use of our resources because of a jog in the program. And it was our judgment that it would be better to schedule the program then on the basis of the money that we had actually available.

Mr. RIEHLMAN. Now, if you get the full amount that you have requested in fiscal 1961—that is the $41 million—have you a program that you can set, or a target date in the future when it will be completed if these funds are available?

Mr. HORNER. I should point out to you that these funds we are asking for in fiscal year 1961 will not complete the program. There will be additional requirements in fiscal year 1962 but we do have such a schedule program, yes, sir.

Mr. RIEHLMAN. With this scheduled program, if we furnish the funds that are necessary, this year and next year, will we meet the target date that you have set?

Mr. HORNER. Yes, sir.

Mr. RIEHLMAN. But you will pick up none of the lag time that has been lost because of the lack of funds in the 1960 appropriation?

Mr. HORNER. The program is just not so scheduled, that is all.

Mr. SISK. Let me ask you this, Mr. Horner. Last year you were given what, about $385 million for research and development funds? What was your total research and development for NASA last year?

Mr. HORNER. $320,350,000.

Mr. SISK. This was appropriated. Is that right?

Mr. HORNER. Yes, sir.

Mr. SISK. Let me ask you about the priorities. I am sure you have priorities over there now. What is the priority on this 1.5-million-pound-thrust engine?

Mr. HORNER. In our program the priority we apply to work on this engine is very high. I cannot say it is the highest in our program, because we have not established a national priority on this program, we haven't felt that it was necessary or useful.

It does hold a very high priority in our total program.

Anticipating your next question, however, I would point out that regardless of priority there are a limited number of places where we can make program reductions without doing permanent damage to the whole NASA organization and the ongoing program.

In other words, we really don't have latitude to save $30 million by reducing the number of employees we have. This would require a tremendous reduction of the number of employees and we would decimate the whole organization. We did have to make reductions in other programs and we have made vital program changes as a result of that $30 million reduction.

The $6 million reduction in this particular engine development program was our assessed judgment of the best application of the reduction for the overall, long-term health of our ongoing development program.

Mr. SISK. Of course, you pretty well anticipated my next question. Out of the $320 million of research and development money it seems to me as though $6 million—and that is what we are talking about with reference to this particular program; I realize you had a shortage of $30 million on the overall, but, of course, if you had a top priority on this particular program, then with the flexibility which you have to transfer funds back and forth it would have seemed to me that had it had high enough priority in the minds of the administrators of the program that the $6 million could have been found. I am not trying to be critical. I realize you had to assess the situation and do the best that you could under the circumstances.

Mr. MCDONOUGH. Was there a physical barrier?

Mr. HORNER. May I point out some of the difficulties we have in doing this kind of a thing to our program: If we had decided, for example, to reduce obligations on some of the other projects that were further along we would have been in an area where there were already contracts out in various elements of industry and there was also already under fabrication pieces of hardware. To a large extent this was not the case in this engine. But in those cases if we had reduced our obligations to those kinds of projects that had already advanced to this stage it would have meant going out and canceling a lot of contracts, it would have meant termination charges, it would have meant a lot of half-completed hardware that was absolutely useless to anybody, it would have been a complete waste of funds. And so in this kind of a situation we almost inevitably must take these reductions in

the projects that are furthest in the future. And this engine, you see, was 4 years in the future. It had a smaller fraction of the total investment at that time already applied to hardware. So in cutting down on one of these projects, we don't actually terminate work that is now in process, which is extremely wasteful, and I am sure the committee would not want us to do, and what we actually do is slow the rate of buildup, which is important to meeting the schedule.

In other words, we just have to level out the rate of expenditure on that project for some period of time until we recoup the rate with following-year appropriations.

This is the kind of an exercise we went through on this project. We did face the problem, for example, that we had a higher priority program in the Mercury in our estimation, which we treat as the highest priority program. We did have to use some of our transfer authority that you mentioned, and which has been extremely useful to us, in actually transferring funds into Mercury so that we did retain the rate in that program. We had to make many other adjustments.

All I can say, without going through a detailed analysis, a reduction of $6 million in the rate of buildup of the F–1 engine development was in our judgment the best use of the resources that were made available to us.

Mr. SISK. What you actually did, then—just to sum up, so I can have it completely clear in my mind—you had planned on making available to Rocketdyne approximately $30 million. That is what you had programed on the F–1 engine?

Mr. HORNER. Yes, sir.

Mr. SISK. Which was two and a half million dollars a month throughout the fiscal year 1960?

Mr. HORNER. Yes, sir. May I——

Mr. SISK. So you actually reduced that to $2 million per month?

Mr. HORNER. I would just point out that that is an average figure, Mr. Sisk. The previous year it had been at the rate of about $1 million per month. You don't just go from $1 million a month up to $2½ million a month. You build up gradually during the year. It was our intent to finish this year at a rate of slightly more than $3 million a month, to phase into the follow-on year's program. Instead we are going to finish this year, slightly more than $2 million a month.

Mr. SISK. So that next year you have programed about $3.3 million per month overall average.

Mr. HORNER. Yes.

Mr. SISK. In other words, you will go into 1961 at a figure of something like $2½ million with a gradual upgrading and you will wind up the year with something in the neighborhood of $4 million per month. Is that correct?

Mr. HORNER. That is correct and that is about a stable level for this development program then during the test period.

Mr. SISK. I will conclude with one question. I don't want to beat this to death, but this is one of the large items, of course, in our part of the budget. This is one program that I know we discussed at length last year and I think it is very important.

This $41 million, then, is, in your estimation, all that you can feasibly spend. That is, you did not request $45 million or $50 million and

then were cut down, were you? What is your situation on that particular item?

Mr. HORNER. You will recall, Mr. Sisk, that this is one of the items that was augmented by the recent studies we were directed to perform in the super booster program. As a result of this study we actually added to this item, $15 million. It is our assessment that this is now the best balance of resources on this program, considering all other elements of the super booster program also and the schedule upon which we can commit resources to build the vehicle to go on this engine.

Mr. SISK. Do I understand the initial idea was to ask for $26 million and because of this study you increased it to $41 million? Have I understood you correctly?

Mr. HORNER. In the $802 million budget that we submitted to the Congress, the item for the F–1 engine here, was $26 million. However, that in a sense was a rather artificial figure since we were in a position, timewise because of the Huntsville transfer, and because of the recent transfer of super booster development responsibility to NASA, of submitting a figure which had to be in the context of our current budget at that time. However, we were already making a study to identify the optimum level of support and it was as a result of that study that we added the $15 million.

Mr. SISK. In other words, the $15 million is that portion of the $113 million which the President approved—in addition to the budget as it originally came out—to be devoted to this particular program?

Mr. HORNER. Yes, sir.

Mr. MCDONOUGH. Is the 1.5-millon-pound-thrust an arbitrary figure or could we do it faster if we built two 1-million-pound-thrust engines?

Mr. HORNER. These specific thrust levels must in the final analysis have some element of arbitrariness about them. They are a balance between what we think is the logical next step based on our current experience. As I mentioned earlier we had already seen the development and successful firing of a 400,000-pound-thrust chamber. That engine actually was run with components that were sized at a half million pounds—500,000 pounds. I believe the current contract calls for the development—and I would ask one of my associates to correct me if I am wrong about this—calls for the development of this engine at a nominal level of a million pounds with a demonstrated growth to 1½ million pounds, and I am fully confident, the way developments usually go, that it will be qualified at 1½ million pounds. The firings to date on this particular chamber have been nearer a million pounds actually than they have been at a million and a half pounds but the performance parameters have been demonstrated which will produce the million and a half pounds.

Mr. MCDONOUGH. Wait a minute. Do I understand the chamber for this engine would be the same size for a million pounds thrust, but the design of it will be built up without enlarging it, to make it a million and a half pounds?

Mr. HORNER. That is correct. The chamber has been fired at something like 10 percent over a million pounds. However, by increasing the chamber pressure, the million and a half pounds—

increasing the chamber to the nominal design level, the million-and-a-half-pound-thrust level will be reached.

Mr. McDonough. Then there would be no advantage in building a million-pound-thrust engine?

Mr. Horner. It has been the history of the engines that they grow through maturity, anyway.

Mr. Sisk. Has the staff any questions?

Mr. Wilcove. As the chairman says, we don't want to beat the F-1 engine into the ground. As a matter of fact, we want to get it off the ground.

I personally regard the F–1 engine as more important if not as spectacular, as Project Mercury.

Let me ask you a few questions about it and see if we can't develop something on this. The United States has a thrust of about 380,000 pounds now. Our maximum. For more than a year now, the Russians have had around 800,000. Now we are striving through the Saturn rocket to obtain a thrust of 1.5 million pounds. I think we can assume as a matter of logic that the Russians, already being ahead, will try to keep ahead of us. By the time we obtain a thrust of one million and a half pounds we can assume the Russians will have not only that but more. So it would appear to me that the Nova project, which would give us anywhere from 6 to 10 million pounds of thrust and which would take a very long time to produce, might be our one big chance of not only catching up with the Russians but possibly surpassing them.

Now, as I see it, you have traded a year or a year and a half on the development of the F–1 engine, for $6 million. Would you say that is a correct conclusion?

Mr. Horner. That is the situation, yes, sir.

Mr. Wilcove. Your most important project you consider to be Project Mercury?

Mr. Horner. Yes.

Mr. Wilcove. What would you say is your next one?

Mr. Horner. The development of Saturn.

Mr. Wilcove. And after that?

Mr. Horner. I don't think we have focused exactly on this question but I would say certainly the F–1 engine is very close, after the development of Saturn.

Mr. Wilcove. It would be about third?

Mr. Horner. We are very conscious of the fact that we have to have a continuous flight program. We can't focus entirely on the late 1960's to produce something. That is not intended to be facetious in any way because we would have little value in producing this kind of delivery capability unless we also had the capability to use it. And there is a tremendous amount of work to be done in the development of spacecraft to actually use the load-lifting capability that we are developing. We don't feel confident to start out and make the optimum development of a 40,000-pound orbital item. We have things that are very attractive to do with space vehicles that can be lifted by the Centaur, for example.

Mr. Wilcove. Do you say that the 12 to 18 months' lag in time, then, isn't too important because we might not have a space vehicle ready to be used with it if we had the F–1 before that time?

Mr. HORNER. I would not say it is not very important. I don't think we can be that wise at this period in time. I can only point out that we certainly have our work cut out for ourselves to properly use the space vehicle weights that we currently have scheduled in the time periods in which they are scheduled to be available to us. And I would also point out that in our program planning we cannot look upon competition with the Russians as the only criteria for developing these vehicles. There is a tremendous amount of scientific exploration of space near the Earth, the cis-lunar space, and the space of the near planets which is available to us before we require load lifting capabilities in excess of those the Saturn provides.

Mr. WILCOVE. Is there a question in the minds of NASA that if the F–1 engine had been developed in 42 to 48 months, there was a good possibility that when the F–1 engine was ready for use, a space vehicle would not also be ready?

Mr. HORNER. I would like to emphasize one other thing and I think this is of more importance: The original contract called for what we call flight qualification of the F–1 engine in 42 months. Now, by rather arbitrary definition, flight qualification means that a rocket engine has been run a given number of seconds and has done a given number of tests and met certain specific conditions. It in no sense of the word is ready for the propulsion of a vehicle at that time.

It requires literally hundreds of tests of all different kinds, even after flight qualification, before it is finally determined to be a reliable engine upon which we would want to invest tens of millions of dollars in a vehicle and payload.

Whether or not we had this engine flight qualified in 42 months or in 60 months, you see does have some bearing on when it becomes a reliable engine through successive testing.

It is also somewhat a function of the tempo at which we test after it becomes flight qualified and this will be more dependent upon our assessed need for the vehicle in the middle sixtys and the late sixtys.

Mr. WILCOVE. Well, I believe there was some planning, at least tentative, that the vehicle would be ready for flight use, if I may put it that way, in about 6 years. That schedule would be delayed to seven or seven and a half on that basis?

Mr. HORNER. The earliest proposed experimental testing of such a vehicle in our current program I believe is 1968. So it would not really be likely that a useful vehicle—I am speaking now of what we have called the Nova class of vehicles—will really be useful in the sixty's.

Mr. WILCOVE. Is it not your thought to use the F–1 as a booster for a space vehicle?

Mr. HORNER. As a single engine?

Mr. WILCOVE. Yes.

Mr. HORNER. We are very conscious of the fact that the F–1 produces the same total thrust that the Saturn does. In these kinds of developments it is always desirable to have a backup. Something up your sleeve in case you have what we would term a development failure.

It is certainly true that should we find problems that are currently unanticipated in the Saturn, it might be desirable to base a Saturn-size vehicle on a single chamber of the F–1 engine.

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Mr. WILCOVE. What plans are you developing for a space vehicle to be used with the F–1 engine, or Nova?

Mr. HORNER. We currently have no plans in work for a spacecraft on a Nova vehicle because we do not at the present time have the Nova vehicle defined.

Mr. WILCOVE. Is there a good possibility that you might have a Nova, for example, ready for use and no space vehicle to use it with?

Mr. HORNER. We could not say that at this time; no, sir. It will certainly take us as long to develop the F–1 engine and the Nova vehicle as it will take to develop the spacecraft to go on top of it.

Mr. MCDONOUGH. As far as spacecraft is concerned, you could test the million and a half with a satellite.

Mr. HORNER. I didn't hear, Mr. McDonough, I am sorry.

Mr. MCDONOUGH. You are speaking of a space vehicle of what nature?

Mr. WILCOVE. Any vehicle that would be adaptable to a 1½-million-pound-thrust, or 6 to 10 million, for that matter.

Mr. MCDONOUGH. What weight?

Mr. WILCOVE. Well, it would be quite——

Mr. SISK. You are talking about the Nova configuration which hasn't gone far ahead enough—you are talking in terms of 40,000 pounds of satellite weight, are you not?

Mr. HORNER. I would emphasize also, Mr. Sisk, that it has only been a concept. But if you talk in terms of a total first stage thrust on the order of 10 million pounds, then this will permit you to put in a 300-mile orbit, a nominal weight of something more than a quarter of a million pounds. We don't have a good idea today as to how we would use that size of vehicle in a 300-mile orbit, but this is a nominal number used for comparative purposes, and we undoubtedly would use a vehicle of that size for deep-space expolation where you have a larger total impulse requirement.

Mr. SISK. In looking at some graphs here not too long ago on a Nova configuration—I don't know whether they came from your people or some that I saw in Huntsville, with Dr. Von Braun, some time ago—and maybe these were some real dreams, I don't remember, but it seemed to me that it indicated a 40,000-pound spaceship to the Moon for a soft landing and return from the Moon.

I understand many things are involved in a soft landing, such as the fuels that would have to be carried to have the thrust to get off the Moon and to return, and for the fuel to be required for another soft landing on the Earth.

That is where I got the 40,000 pounds. Maybe I was entirely wrong on that, but I thought that was on a Nova configuration.

Mr. HORNER. I think that has been shown on a Nova configuration. I think that actually was a weight that was at one time talked about in relation to a four-barreled Nova conceptual vehicle of 6 million pounds, whereas the six-barrel configuration—and I emphasize again these are only concepts—have been with soft-landed weights on the Moon of something a little more than twice that total weight. In the neighborhood of 90,000 to 100,000 pounds on the Moon, before return.

Mr. SISK. As I recall, this was a four-barreled configuration. It might not even have been the Nova. I was thinking it was the Nova, and I was just trying to recall. This was some time ago, and, as I

say, maybe it was quite a pipe dream, but I do recall having seen some type of craft which they figured could carry, of course, several people along with it to do the job.

Mr. WILCOVE. Would the Saturn have the capability of putting a man on the Moon and bringing him back?

Mr. HORNER. The Saturn does not have the capability of putting a man on the Moon from a direct Earth ascent. There have been studies which provide for landing a man on the Moon and returning him to the Earth, based on an operation where several Saturns are used from an Earth-based launch to rendezous in orbit about the Earth. Some of these Saturns would carry extra fuel as payload into orbit. This fuel, then, would all be brought together in one lunar vehicle which then would be launched from the orbit to the Moon, make a soft landing, and return to the Earth. This is the only way in which Saturn can be used to produce a manned vehicle on the Moon and return.

Mr. WILCOVE. I am inclined to think that may take longer than actually getting the man on the Moon.

Mr. HORNER. Different people have different judgments in this respect.

Mr. WILCOVE. In order to get a man on the Moon we would need something like a Nova configuration or a breakthrough, such as a nuclear rocket, for example.

Mr. HORNER. I think that is an accurate statement; yes, sir.

Mr. WILCOVE. So we have to look far into the future if we have any plans for getting a manned expedition to the Moon?

Mr. HORNER. My statement has been that this is certainly not going to occur in our program in this decade.

Mr. WILCOVE. But you wouldn't want to predict the Russians won't be there in this decade?

Mr. HORNER. That would be extremely speculative, from my information.

Mr. WILCOVE. With regard to the F–1, what's the total cost of the program? It is not $105 million, is it?

Mr. HORNER. No. As I said, this was the original projected cost for the program to the flight rating test. Now, this also was based on the original contract time. As we extend contract time, these developments inevitably become more expensive.

Mr. WILCOVE. What do you estimate now to be the total cost of the program?

Mr. HORNER. Perhaps Dr. Hyatt or Mr. Mitchell can give a better estimate than I can.

Mr. HYATT. I would prefer to provide it, sir.

Mr. WILCOVE. Apparently it is substantially more.

Mr. HYATT. It is substantially more.

(The information requested is as follows:)

The total cost of the original basic contracts which extends only through preliminary flight rating tests of the engine, is being reestimated by Rocketdyne. The delays in the program schedule which occurred because of funding shortages during fiscal 1960 caused an increase of approximately $8 million in the total cost of the contract. The revised cost of the program through preliminary flight rating tests has been indicated by Rocketdyne to be very near $113 million.

Mr. WILCOVE. Now, the test facility at Edwards Air Force Base, when will that be ready?

Mr. HYATT. The stand 1–B will be ready to take this engine the early part of next year.

Mr. WILCOVE. And that is being financed and built by the Air Force?

Mr. HYATT. That is right.

Mr. SISK. Could I interrupt the gentleman for just a moment?

I had hoped to adjourn at 4 o'clock, and it is now 4:15. I didn't want to interrupt.

If you have quite a few more questions, Mr. Wilcove, why don't we carry over until Monday morning?

Are we going to have these witnesses before us Monday morning?

Off the record.

(Discussion off the record.)

Mr. SISK. I believe Mr. Riehlman had a question.

Mr. RIEHLMAN. We have been talking about spacecraft, and we are very much interested in the Saturn program which would have a million and a half pound thrust. Now, we are planning for a space vehicle to go along with that operation, are we not?

Mr. HORNER. Yes, sir. We are very early in the planning stages for the spacecraft to fit the Saturn vehicles. I would point out that the early shots on the Saturn development program are primarily for vehicle development. It is always a matter of judgment to provide the proper balance between the investment you are willing to make for a spacecraft on the development vehicle because the reliability cannot be expected to be very high.

The first three shots in the Saturn program, you will recall, are simply a test of the first stage, and it will only go a matter of a few hundred miles down range.

The next three shots are tests of only the first two pages.

The first six shots you might say do not produce useful spacecraft launching capability.

Starting with the seventh vehicle, assuming success on the first six, there is a possibility for putting some payload, and payloads of increasing complexities as we go through the number of vehicles and demonstrate a more reliable launching vehicle.

Mr. RIEHLMAN. Won't that give us the basis for using a similar spacecraft on the F–1 engine? The same thrust?

Mr. HORNER. Except, I believe, Mr. Wilcove was speaking in terms of a spacecraft to be used on what we call the Nova concept, which is again a factor of four to six times bigger than the Saturn and, therefore, could have a still larger spacecraft than those we would design for Saturn.

It is a development step in that direction. You are absolutely right, Mr. Riehlman.

Mr. RIEHLMAN. That is what I am trying to develop. That is a step in that direction.

Mr. HORNER. And we feel it is a very necessary step. We just don't know how to anticipate all of the problems that we will have.

Mr. SISK. I think Mr. Wilcove had one short question.

Mr. WILCOVE. Has there been any transfer of funds from the F–1 program to any other program?

Mr. HORNER. No, sir; there has not been.

Mr. SISK. I don't know just what room we will meet in Monday morning. We will have to notify you. You will let us know as soon as possible, Mr. Wilcove.

We will adjourn, then, until Monday morning at 10 o'clock, at which time we will resume where we left off here today.

I thank you, gentlemen.

(Whereupon, at 4:15 p.m., the subcommittee adjourned until Monday, Feb. 22, 1960, at 10 a.m.)

1961 NASA AUTHORIZATION

MONDAY, FEBRUARY 22, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE No. 4,
Washington, D.C.

The subcommittee met at 10:10 a.m., Hon. B. F. Sisk (chairman) presiding.

Mr. SISK. The subcommittee will come to order.

Before we proceed with our consideration of this backup material, I want to take this opportunity to welcome a new member of our subcommittee and of the full committee.

I am sure our chairman at the next meeting of the full committee will have some comments. Congressman Morris from New Mexico has just recently been appointed to the Committee on Science and Astronautics. We are very happy to welcome you, Tom, and I am sure you will make a very great contribution to this committee.

Mr. MORRIS. Thank you. It is a real pleasure to be here, Mr. Chairman.

Mr. SISK. Now, when we adjourned on Thursday last, we were considering that portion of the authorization bill dealing with liquid rockets.

We had under discussion the situation with reference to the F–1 engine, and just what had occurred to bring about apparently some substantial delay in the development of this engine.

Since our discussion Thursday with Mr. Horner and you other gentlemen from NASA, I have become increasingly concerned about what is represented here in this situation, specifically, as it has to do with the attitude of NASA.

As I indicated Thursday, I hope you understand there is no personal criticism implied or otherwise in this. But as a committee having jurisdiction, as our Committee on Science and Astronautics does have, and joint responsibility, I think, with NASA in our space program, I am real seriously concerned about the attitude that seemed to me was represented in the handling of these funds.

I appreciate the fact that you made the statement last Thursday that the cutback in the program and the delay of up to 18 months was due in some part, as I understand from you, because the Appropriations Committee did not grant the full amount. Yet, since that time, in going over the research and development program, I see you were actually given about $335 million in research and development money last year. Of the total cut represented by the Appropriations Committee in research and development requests there was only about $18 million and not the full $30 million we were talking about Thursday.

Actually, in research and development I think it is only $18 million or $18.5 million, and yet a big bulk of that came out of this F-1 program.

We had under discussion the matter of priority here. I think this is vitally important.

Before we start our questioning this morning I want to read into the record a few comments that I feel have a definite bearing on this. I first want to open by a statement from Dr. Eberhardt Rechtin, of the Jet Propulsion Laboratory, who, after all, is an NASA official.

In a speech he made in Los Angeles fairly recently—and this again is to me evidence of an attitude and an attitude that I think must be changed—he says:

> At the present time one of the most remarkable features of the U.S. position is the almost complete lack of urgency in the space program. The NASA budget is now somewhat less than what the United States pays to ship and store surplus wheat. Our space program is less than 2 percent of our defense budget. The space program costs less than $10 per year per U.S. adult or roughly one evening's entertainment per year. Putting it in somewhat different words, continuing at the present level is largely a waste of money.

I think that is a tremendously significant statement.

Dr. Rechtin added:

> At the moment we are paying for the privilege of being the perfect straight man for the Russians.

Now, this is a statement by an official of NASA, and a rather high official. He is Chief of the Telecommunications Division at the Jet Propulsion Laboratory.

Whether you agree—and many people may disagree with his statement—as I go back and review your testimony Thursday, Mr. Horner, I see reflected in your own statements at least a similar attitude.

I think this is the thing that is important—this whole attitude. I want to put this in the record and then I want you to make a comment on this if you will, Mr. Horner, because I think this goes to the crux of the whole situation.

I mentioned here this statement that Dr. Rechtin made from the standpoint of the fact that what we were doing at the present time was largely a waste of money. Of course, if all we are going to do is simply leisurely proceed along here and probably not spend the money, I am inclined to agree. Let the Russians go ahead and do the job and put their people on the Moon, and then maybe, ultimately, they will make available to us some of their knowledge or the loan of a ship to get up there.

Now, I assume to some extent this was the feeling that Dr. Rechtin had, that unless we pushed ahead and took some leadership, then, actually, didn't there arise a question as to whether the whole thing was a waste of effort.

Getting back to our Thursday discussion, you advised us that because Congress appropriated $30 million less last year than was authorized for the NASA budget for the current fiscal year, you were compelled to cut back the big engine program by $6 million and as a result the development of this engine was delayed by 12 to 18 months. I believe you also pointed out that a clustering of the F–1 engine into a Nova configuration provides apparently the only practical method of sending a manned expedition to the Moon.

There was also raised the possibility of such capability being obtained through the development of a nuclear rocket engine which apparently is not being pushed too strongly at the moment. This, by the way, we are going into later at some length.

The conclusion is therefore inescapable that the delay in the development of the big engine project means the postponement by a year to a year and a half of our landing a manned expedition on the Moon.

I would like to explore for a moment the reasons why you felt that the program for the big engine project should be reduced by $6 million. It is significant to my mind that although the cut in authorized funds was approximately $30 million, the reduction in the research and development fund amounted to only $18½ million. Therefore, the reduction of $6 million, almost one-third of the research and development cut, was absorbed by the big engine program.

You testified that the Project Mercury had the top priority at NASA followed by Project Saturn, and then apparently by the big engine project, but when the funds were appropriated last year—and I think this is significant, Mr. Horner—Project Saturn was an Army program and did not figure in your program at all. Thus, it would appear that the very substantial cut you made in the big engine project was made to your second most important program.

NASA has made no plans for a manned expedition to the Moon in this decade. Your target date is a vague "in the 1970's"—and this I am taking from your own statement, Mr. Horner, and you certainly will have an opportunity to correct that if I have the wrong impression.

While it is true that it would take many years of planning to send an expedition to the Moon, it also necessarily follows that the sooner efforts in that direction are begun the sooner we will get there.

No one has any serious doubts that the first man on the Moon will be either a Russian or an American. We are concerned certainly as to which one that will be.

General Medaris, the other day, told the committee that the Russians have boasted that they will celebrate their 50th anniversary of the Communist revolution on the Moon in 1967. Medaris stated:

> My own personal feelings are very strongly in the direction that we should have begun some time back the necessary long-range preparation that would lead to our capability for a manned outpost on the Moon by 1966 or 1967.
>
> I don't know that we could now make those dates, but we could still come awfully close to them if we went about it.

That is the end of the quote by General Medaris.

Recently, representatives of Vought Astronautics presented this committee with a program they said could place a manned expedition on the Moon in 8 years, by 1968, if the effort were begun immediately.

General Medaris and Vought Astronautics are not the only ones that think man can reach the Moon during this decade rather than in the 1970's.

Dr. Herbert York, Director of Defense Research and Engineering, told the Select Committee on Astronautics and Space Exploration in 1958 that a manned expedition to the Moon was possible by 1968—and here is the significant thing that he said—even by 1965, "if a very high priority were placed on this goal."

York's prediction bore the endorsement of Roy Johnson, then head of ARPA.

As a member of the select committee back in 1958, I am well aware of not only Dr. York's statement but, of course, the statement of many others before the select committee at that time.

There were others who felt the same way. Among them was Maj. Gen. Bernard A. Schriever, commander of the Air Force's Air Research and Development Command, who told the select committee that—

> it should be possible by 1968 to return to the Earth from the Moon a payload capable of carrying a crew of one or two men.

Brig. Gen. H. A. Boushey, Director of Advanced Technology for the Air Force, was another who thought that a manned vehicle would or could return from the Moon by 1968. Boushey went further. He predicted that construction of a manned lunar base would begin in 1969.

Others who thought a manned expedition to the Moon was possible during the present decade included: Dr. Wernher von Braun; James H. Doolittle; Dr. Walter R. Dornberger of the Bell Aircraft Corp.; Donald W. Douglas, chairman of the board of Douglas Aircraft Co.; Dr. Louis G. Dunn, president of Space Technology Laboratories; Krafft A. Ehricke of Convair; Alexander Kartveli of Republic Aviation Corp.; James A. Reid of Astrodyne; George H. Stoner of Boeing Airplane Co., and George S. Trimble of the Martin Co. So you see that there are many men, experienced in this field, who feel that we can and should get to the Moon this decade rather than wait for the next.

It disturbs me, therefore, that your agency has no plans for attempting an expedition to the Moon until the 1970's. You told this subcommittee last Thursday that:

> We currently have no plans in the works for a spacecraft on a Nova vehicle because we do not at the present time have the Nova vehicle defined.

Then you went on to say:

> It would certainly take us as long to develop the F–1 engine and the Nova vehicle as it would take to develop the spacecraft to go on top of it.

Now, I have tried to set out why I feel it is so important for this country to make as early a start as possible on a determined effort to reach the Moon. I find it difficult to believe that your agency considered this goal as very important if you are willing to trade $6 million for 12 to 18 months.

Let me ask you this. When you look at the $18.5 million in research and development funds which Congress failed to give you, keeping in mind that Congress did vote $335 million in research and development funds for your agency last year and keeping in mind that the big engine project was your second most important project, was there any other project which suffered as large a cut in funds as the program for the big engine?

Now, I realize that that is a rather lengthy statement, Mr. Horner. It may sound somewhat critical. Frankly, it is critical, not of you, nor of those who are with you, but it is critical—and I intend it to be so—of the people who are apparently responsible for this whole attitude of complacency in this field.

I expect it be so taken.

Now, will you make a comment on the overall attitude of your agency with reference to the F–1 engine, how important you think it is, and what you propose to do about developing a priority for it in the immediate future?

Mr. HORNER. Your statement is very comprehensive, Mr. Sisk, and it touches on a tremendous variety of points which I find difficult to address myself to individually without some study of the points individually, but I will try to be responsive to what I think is the general sense of the question.

Mr. SISK. Fine. You go ahead. I think there isn't anything in the portion of the budget which we are discussing which is more important than where we are going in our efforts to really get ahead in this field. It seems to me as though they are all tied up in this bundle with this F–1 engine or in a nuclear engine which we will discuss a little later.

STATEMENT OF RICHARD E. HORNER, ASSOCIATE ADMINISTRATOR, NASA

Mr. HORNER. I would like to address myself first to the question of whether or not there does exist in NASA a sense of urgency with regard to the space program as a whole, and ultimately manned flight to the Moon as one of the major objectives.

I can categorically say at the beginning that there is a very real and strong understanding of the importance of the space program as a whole, of having an objective to which our space program is addressed.

The sense of urgency among our field personnel and among our headquarters personnel certainly shows very strong in their motivations, and we feel that we are setting forth our very best efforts in formulating the program with the resources that are made available to us and in, if I may use the term, "selling" the importance of this program to all of our associates in Government and to the American public. We do feel that it is important.

Now, to be more specific, as regards the quotations from some of the very eminent scientists and administrators whom you have mentioned, I don't really feel that it is useful for me to debate when a specific task can be done, because there are perhaps too many uncertainties, but the biggest uncertainty of all relates not to when something can be done in the space program, but when it will be done.

We, in the final analysis, must plan our program on our judgment of when certain things will be done because these overall long-range objectives are dependent upon a whole systematic chain of events and it would be most wasteful and we would certainly be subject to very well-placed criticism if we spent our money in a way in which we emphasize an objective which we could not attain without earlier events taking place successfully. We should not spend our money on attaining capabilities which could not be used without the advancement of the whole breadth of science and technology that is required for the attainment of the ultimate objective.

I think you will find that in most of our testimony we have expressed our opinion, our judgment in our long-range plan for example, as to when these things will or can be accomplished in terms

of the overall controls on the system, and certainly one of the most important of these is the resources that are made available to us.

Now, let me address myself specifically to the F-1 engine, to the effects on it of the reduction in the appropriation furnished by the Congress last year.

It is certainly true that the F-1 engine is high on our priority list.

I don't think I made the statement that it was second. I think it was certainly near the top of those things that we considered after Saturn and the Project Mercury, and of course, I recognize that Project Saturn was not, last year, a part of our program.

It is extremely important in our program.

It is also equally true that it is one of the longest range items in our program. Its actual utilization is one of the things that is furthest in the future.

I would like also to acknowledge the fact that of the $30 million reduction, only $18 million was from the research and development fund. What it amounts to is the $30 million reduction was a reduction from $530 million, the $18 million reduction was a reduction from $338 million. These are round numbers.

In deciding, in making our judgment as to where these reductions are to be taken, we have many different factors to consider. One of the more important, I think, is the one I mentioned last Friday of where we can take reductions and do least damage to the ongoing program.

In a research and development program that is largely involved in hardware, there are very real constraints on what one can do sensibly about contract terminations, about project cancellations, without being very wasteful of public funds.

We, in the process of reforming the program, went through an operation which I can run through briefly for the subcommittee here this morning if it is useful.

We have in the backup book on page 109—I will just call it to your attention—a listing of all of the research and development program.

In accepting any reduction in the dollars on which that program is planned, we must go through this account item by item and ask ourselves, "Well, now, where is the best place to get money doing the least damage, recognizing the needs of the individual projects," and we also recognize that different people would have different judgments as to where these dollars can best be obtained.

I would point out some of these items in which we really have very little flexibility.

The first item of support of the NASA plant, for example, is a very considerable item—$22 million—about 8 percent of the total—is directly related to expenditures of the Government employees we have on the rolls.

As you know, we have limited flexibility in hiring and firing of such employees. If we were going to make material savings in that account, it would mean a marked reduction in our scientific manpower. This would not only have the difficulties of doing away with the employment of Government scientists, but it would also decimate our capability of managing the program and doing research and development in future years.

In the next account item of research grants and contracts, we did make a substantial reduction in that account. We had originally asserted a requirement of a research grant and contract program of $10 million. This account finally ended up with just about half that value, as you can see.

This largely represented research grants and contracts that had already been made to American universities and nonprofit institutions.

We value very highly our relationship with the scientific community of the United States. My personal feeling is that the amount that you see there of $4,950,000 is less than the minimum requirement to get the proper benefit out of the American scientific community to the national space program.

In the next account, the scientific investigations in space, this is almost the reason we are in business. It is extremely important to the ongoing space program that we understand the space environment in which we work.

It would be foolhardy, to say the least, to take as our objective manned space flight to the moon without having a real understanding of the environment through which men must fly in order to get to the moon.

The investments we have there for sounding rockets, scientific satellites, and lunar and planetary exploration are really investments in this understanding. They are directly applicable to the objective which we were and are discussing.

We do not feel that we can reduce that at this time below that level, or the rate of scientific findings will fall so low that we will not be ready—we would not be ready to use the F–1 engine for manned lunar flight should it finally occur—excuse me—when it finally occurs.

Mr. SISK. Let me ask you this right there. Is there some doubt in your mind about this program, Mr. Horner?

Mr. HORNER. Mr. Sisk——

Mr. SISK. I am thinking now of the F–1 engine.

Mr. HORNER. This leads to a statement which you made earlier, which I wanted to correct if I may.

I think you stated, you quoted my testimony of last Friday as saying the F-1 engine was the only practical means for manned flight to the moon. I don't believe you will find that is an accurate quotation.

Mr. SISK. I am just looking for it. As I said to you, if I misquoted you in any way, I want you to correct that because that certainly was the impression that I drew in answer to some questions, Mr. Horner.

Mr. HORNER. I don't have my testimony here, Mr. Sisk, but let me recall what I think I said, what I am certain was my intention.

Mr. SISK. You go ahead.

Mr. HORNER. I said the F–1 engine clustered to provide a multimillion-pound thrust first-stage capability, which was the only way we could foresee at this time for launching a manned expedition to the moon directly from the ground with chemical engines.

Mr. SISK. Yes. That is right. In other words, the Nova configuration, right?

Mr. HORNER. Yes, sir. I would point out two qualifications in that statement, and I probably should have put a third one in it. If I had said, directly from the ground, which is one constraint, with liquid chemical engines, I would have been better satisfied with my statement,

and I would like to modify the record to have it reflect that small change.

Now, there are other possibilities. One, of course, is the nuclear engine which we are going to discuss later with the subcommittee, which does offer possibilities—and which is very strongly endorsed by some of our people. Another possibility involves the launching of Saturn-size vehicles, arranging them so that they will carry fuel in their payloads, rendezvous in orbit for inflight refueling, and proceed to the moon from that position. That may sound to have many development problems in it; I am sure it does.

There are very capable scientists however who feel that the development problems in such a scheme are less demanding than the development problems in the Nova first stage.

A third possibility then is the development of the large-grain, solid-propellent, first-stage booster which we discussed and explained last Friday, which we in NASA have a very real long-term interest in, albeit the early large grain work that is going on is being carried out in the Department of Defense.

I just wanted to insert that, Mr. Sisk, because I am not questioning whether or not manned flight to the moon will occur; I think we all must have some doubt in our minds specifically as to whether it will occur with the Nova vehicle at this point of the game.

Mr. SISK. I appreciate your clarification on that. As I said, if I misunderstood any of your testimony Thursday, you may correct it. Of course, the thing that disturbed me and it still disturbs me, is that apparently NASA has conceded—and maybe I am wrong—but the statements that you made Thursday, and other statements that I have understood were made, that NASA has completely conceded that a manned expedition to the moon is somewhere in the seventies.

This is the thing that, of course, my whole statement was directed at. This idea of a manned expedition to the moon becomes, then, in a sense—I will not put it that way. I feel that a little bit, but——

Mr. HORNER. May I say, Mr. Sisk, that we have certainly acceded to that position in terms of the amount of resources that we have to work with in 1959, in 1960, and those which we are requesting for 1961.

Now, I would also say that that is biased by our recognition of the difficulties of the task and I don't think anybody, even among the very able scientists that you have mentioned, really recognizes the research and development effort which must be invested prior to such an accomplishment.

We are spending many hours every week addressing ourselves exactly to that problem. I am not saying that if we had virtually unlimited resources available to us that it wouldn't be possible to have a manned flight to the moon in the latter part of this decade.

I am saying that with the program we have planned, based on the first 2 years of foundation, that we have laid down, we will not realize manned flight to the moon in this decade.

Mr. SISK. Well, I——

Mr. HORNER. I certainly would not want to mislead the Congressman to the effect that we think it will occur in the next 10 years.

Mr. SISK. I appreciate the sincerity and the honesty, your sincerity, Mr. Horner. This, of course, is of real concern to us.

We heard the military, man after man, sit here toward the end of our hearings and state that there is a definite need in defense today for a million-pound-thrust engine. This was said by General Lemnitzer. It was repeated by General Trudeau. It was stated by the Secretary of the Army. It was verified by General Medaris, and yet we apparently are talking here about delay in something that to me is as vital as this.

Mr. RIEHLMAN. Will the gentleman yield?

Mr. SISK. In other words, I will yield the floor.

Mr. RIEHLMAN. I think the record should be pretty clear that there is just as firm an opinion on the opposite side that a million-thrust and a million-and-a-half-thrust engine is not necessary for the military posture at the present time. We have had those very same statements.

This is very true as far as the Army is concerned. Medaris and Lemnitzer and all the rest of the people who were up here, I will agree said in emphatic terms it was necessary for our defense posture, but by equally as good testimony we have had the same story on the other side from the Air Force and from the Navy that that is not their opinion.

So we have a difference of opinion.

Now, to get back to the F–1 engine, let me ask you this, Mr. Horner. Is it not true that—and I think you emphasized it this morning—there is a tremendous amount of other work other than the construction of this engine that depends upon our getting to the moon?

Mr. HORNER. Yes, sir, that is certainly true.

Mr. RIEHLMAN. Let me ask you this. Do you feel if we pushed this engine at a faster rate through NASA, the construction of the F–1 engine, we are going to have the other capabilities to put the man on the moon, Mr. Horner?

Mr. HORNER. Not within the context of our present program we will not, no, sir.

Mr. RIEHLMAN. Just what has got to be done within the context of that program to accomplish that? Can you give us any idea at all?

Mr. HORNER. Prior to a manned flight to the moon, the list of things to be done is almost overwhelming. I would have no confidence whatsoever I could even begin to call them all to mind without assistance and reference this morning.

But largely they are represented by the listing of things that we have right here in this research and development program.

It becomes only a question of rate and scale in each one of these areas as regards when something will happen in terms of a long-range objective such as manned flight to the moon.

Each one of these things can be done faster, and they certainly will spend more money in the process.

I would also point out that there is a level of effort in each one of these areas which, if exceeded, the rate of return in new technology and new scientific findings is diminished—I say the rate of return is diminished. This is the return per dollar.

Now, it would be a little bit egotistical, I think, for us to say that we have discerned just exactly that level in our program, because I don't think we are quite that smart.

We think we are close to the level of program effort in which we are pushing most of these areas about as rapidly as we can develop the technology—the foundation for it.

There are some of these areas in which I would feel more comfortable if we were doing a little more in terms of providing insurance to ourselves.

Areas of development which are risky, which we don't see the answers to, right at the moment, I would feel a little more comfortable if we were seeking alternate ways toward solutions.

I cannot assert that any one of these areas is of overwhelming importance to our long-range goals.

Now, I think one of the long-term problems we have in the organization and the management of the space program impinges on this very issue, the international situation has been such that public attention has focused largely on our weight-lifting capability.

It is at some point necessary to emphasize the fact that our weight-lifting capability is only one of the many very difficult areas of research and development which must be mastered to reach our long-term objectives.

At some point it is going to be, in the minds of many people—I would predict, it will be a minor factor, because it will be the factor which we have in hand. It is currently the area in which we are working very strongly.

I made repeatedly, during these hearings, the point that we are spending almost half of our money—half of our research and development money—on this very element of improving our weight-lifting capability. But we must—we would be irresponsible if we did not—pay attention to all of the other areas that must be brought along, too, in order to have a balanced program and a program which will produce a product that is commensurate with the expenditures we are making.

Now, there is one area in our program, which one could say is not addressed to this particular objective. In going down the list of items which we were exploring, trying to find a better place to reduce money instead of the F–1 engine, I had just come to the one of satellite applications.

I would only call to the committee's attention that in fiscal year 1960 our total investment was barely $11 million in satellite applications.

This is the one area that offers perhaps the most immediate promise for direct results, for a direct benefit to mankind, and specifically to the people who are putting up the money, the American taxpayer.

We have reduced that program, we think, in the face of the reduction in the appropriation last year, to a bare minimum, and this is certainly one of the areas in which I personally, as I said, would feel more comfortable if we had more resources.

That program also was reduced in the process of absorbing the $18 million deficit in—decrease in our research and development.

The next item we have is manned space flight, and as we mentioned earlier, it is our highest priority item, but it, in itself, is certainly very easily recognizable as absolutely essential before we talk about manned flight to the moon. Its objective is to demonstrate the feasibility and the usability of having manned space flight at all.

From there on the vehicle-systems technology, space-propulsion technology, and vehicle development are all a process of improving our load-lifting capability, the ultimate step of which in our present program is the F–1 engine.

We don't think that we can take out of the program any more of the intermediate steps that we have planned than we have already taken out.

We have taken out the Vega, for example. I think it cost the quality of our program somewhat to eliminate the Vega program. We will certainly make every effort to gain back the technology we would learn from the application of the Vega program in other programs, and I think we will.

I don't think there will be long-term damage to our program, but it did amount to one of the steps that was taken out.

Now, I would just like to make two other points. One is that I am a little bit troubled by my use of the 18-month figure last Friday, or the 12-month figure in identifying the slowdown in the F–1 engine as a result of the reduction.

The facts are that the degree to which the engine program will actually be slowed down is very much dependent upon whether we actually gain the $41 million that we are asking for in this program on the F–1 engine, and, of course, we cannot make program plans—excuse me, we cannot make program contract on this $41 million until we have it in hand, a fact of which I am sure you are all aware ——

Mr. SISK. Wait a minute right there. Would the gentleman from New York yield?

Mr. RIEHLMAN. Sure.

Mr. SISK. I want to ask you about that particular thing.

I agree that under an act, a congressional act, that you have to prorate your program, I believe, by quarters. In other words, you have to apportion it so that it will last through the entire fiscal year.

Yet, on the other hand, in your Mercury program, isn't it true you actually committed and moved ahead at a good deal more rapid rate than what you would have had money to have done the job unless you had gotten through a supplemental?

You were very dependent on a supplemental to carry through that program at the rate you had it scheduled. Isn't that true?

Mr. HORNER. In Project Mercury, and again I would point out this is our top priority program.

Mr. SISK. That is right.

Mr. HORNER. In Project Mercury, we did use the authority provided to us in the Space Act of 1958 in converting research and development funds to funds in other accounts because they were needed on a time-scale earlier than had been originally planned, and we also faced the problem of very real difficulty in the Project Mercury program if we should not get the supplemental funds.

Mr. SISK. The point I was making, Mr. Horner, is this. That is what I wish you would have done on the F–1 engine and that is what I think you could have done. That is, of course, where basically by criticism lies, in that you did not do that. Certainly, in checking the hearing record, I at no time think there was any implication given to the Appropriation Committee that because of their act there was

going to be any slowdown in this engine. So you fellows either neglected to make your story clear here, or still that attitude prevailed of a lack of importance in pushing it forward.

That still, of course, goes back to the whole heart of my criticism here on this. I don't wish to carry this on too far. However, I am really sincerely concerned about it.

Mr. HORNER. Mr. Sisk, I think I need to make one further comment to complete the record.

In the process of the final discussions of our Agency with the Congress last year, after the appropriation for the National Aeronautics and Space Administration had been reported from committee, we did send a letter to various Members of the Congress. I would have to check this to be certain, but I think to the chairman of this committee, I am certain to the Appropriations Committee, advising that this would almost certainly result in the slowdown of the F–1 engine, because we foresaw no other possible way of accommodating the decrease.

So it is not—I don't know where your understanding emanated from as regards the fact that this would not hurt the F–1 engine, because we were certain from the beginning that any reduction in appropriation would almost certainly impinge on this particlar engine.

Mr. RIEHLMAN. Mr. Chairman.

Mr. SISK. Go ahead.

Mr. RIEHLMAN. I would like to have a copy of that letter sent to the chairman of our committee and the Appropriations Committee in respect to the F–1 engine.

Mr. HORNER. Mr. Gleason tells me it was to the Appropriations Committee, it wasn't to the chairman, I am sorry.

Mr. RIEHLMAN. I would like to have a copy of it for the record.

Mr. SISK. I think that would be fine. I would like to have a copy also.

(NASA subsequently informed the committee that Dr. Glennan wrote Hon. Carl Hayden, chairman of the Senate Appropriations Committee, and subsequently made a statement to the Senate Appropriations Committee. No statement or letters were addressed to any House committee.)

(Dr. Glennan's letter and statement follow:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., July 9, 1959.

Hon. CARL HAYDEN,
Chairman, Senate Appropriations Committee,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: Reference is made herein to H.R. 7978, the supplemental appropriations bill passed by the House of Representatives on June 29, 1959. This bill includes a fiscal year 1959 supplemental request and the regular fiscal year 1960 request for funds for the National Aeronautics and Space Administration. Due to several technical points of order being sustained during the debate in the House, the Appropriations Committee's reduction of NASA's funding request were increased from $45,500,000 to $68,225,000. Any reduction in the NASA's tight budget will have a critical effect on the Nation's space program. The Senate Appropriations Committee is being requested to fully restore the

funds cut by the House. The areas in which the reductions have been made and the effects that such reductions will have if enacted are explained as follows:

Year	Amount requested	Appropriation Committee action	House action	Final percent reduction
1959 supplemental	$45,000,000	$41,400,000	$18,675,000	59
1960 regular	485,300,000	443,400,000	443,400,000	9
Total	530,300,000	484,800,000	462,075,000	13
Net cut		−45,500,000	−68,225,000	

1. RESEARCH AND DEVELOPMENT

Funds requested	$354,000,000
1959 supplemental reduced	2,075,000
Fiscal year 1960 reduced	33,070,000

The NASA in discharging its duty to develop and manage a national space exploration program for the United States formulated an orderly and progressive program during fiscal year 1959. This program not only sought to produce immediate and obvious results, but was designed to produce a sound, continuing foundation for anticipated accomplishments in the future.

A reduction in "Research and development" funds which are the fundamental ingredients of this Nation's space effort, at the very beginning of this complex program can only result in crippling our efforts to establish U.S. leadership in space.

In requesting its appropriations, the NASA sought adequate "Research and development" funds to carry out the programs formulated in fiscal year 1959 and to take the first steps toward future programs. Of the $354 million requested for supplemental fiscal year 1959, and fiscal year 1960 funds, $222 million is required to continue contractual obligations started in 1959. An additional $88 million is needed to purchase payloads and to pay flight operation costs and other expenses required to use efficiently the items already being procured through existing contracts. Thus, out of $354 million, $310 million of the "Research and development" sums requested are the fixed costs required to carry out the space program presented in detail to the Congress. The remaining $44 million is required to initiate advanced development of vehicle and payload components needed to improve the technical competence of the United States for flight programs to the moon and other planets.

The proposed cut in R. & D. funding of $35,145,000 would, if absorbed in areas not definitely related to the presently contemplated flight program, reduce the funds available for development of these advanced systems to $8,305,500. Such a reduction in advanced development funding would result in a completely unbalanced NASA program. In order to achieve a new balance in the face of the proposed cut, it will, therefore, be necessary for the NASA to delete scheduled space flights or to slow down the procurement of equipment for these flights and hence to delay important elements of the flight program. Such reduction would seriously retard flight programs having great international repercussions as well as great practical benefits to the United States. Project Mercury, the Nation's first manned space flight project, for example, is the sole item represented in the $20,750,000 R. & D. funds requested in the supplemental fiscal year 1959 bill. The Appropriations Committee reduced this vital sum 10 percent. A reduction in the Project Mercury funding level below the requested sums can only be satisfied by slowing down the Mercury program, thereby jeopardizing the U.S. possibility of being the first nation to place man in orbital space flight. By the same token, cuts may have to be made in the meteorological and communication satellite programs. Such reductions can only be accomplished by deferring certain of the developmental flights proposed in the budget transmitted to the Congress.

2. CONSTRUCTION AND EQUIPMENT

1959 supplemental reduced	$1,525,000
Fiscal year 1960 reduced	5,800,000

The NASA cannot make savings in the "Construction and equipment" program of approximately 10 percent as proposed by the House without reducing the technical capability of the NASA to explore space and to continue U.S. leadership in aeronautics.

The construction program submitted to Congress has two parts: first, those items essential to the discharge of the new responsibilities of NASA in conducting the civilian space program and, secondly, those items required for the conduct of advanced research in the aeronautical and space fields. If the reductions proposed are actually made, then either the new responsibilities, or basic research, or both must suffer. This will jeopardize the Nation's position in aeronautical and space activities.

The launching, tracking, and research facilities requested do not now exist, and a reduction in these funds now will imprudently curtail our national space and aeronautical capabilities in the immediate future.

3. SALARIES AND EXPENSES, REDUCED $3,030,000

The projected increase in the NASA employment level proposed in the President's budget for the fiscal year 1960 was limited to that required to handle the new duties and responsibilities imposed on the NASA by the expanding civilian space program. By the same token the increased requirements for supporting services, particularly in the travel and communications areas, are directly attributable to a significant expansion in worldwide tracking and observation activities required in carrying out 1960 program. These increased 1960 needs in the space flight development area cannot be met by reductions in the area of basic research without jeopardy to our country's long-range position in the aeronautical and space fields. Yet the House action in effecting a 15-percent cut in the number of new positions requested and a substantial cut in the total support costs for the entire agency, if allowed to stand, would result in just such a situation.

The House action is not consistent with the NASA's increasing responsibilities for the success of the Nation's space flight development program.

Responsible officials of the NASA will be available for your committee's hearing on H.R. 7978 to provide information on our program and justification for our request for funds. There is attached hereto the recommended changes in H.R. 7978.

Sincerely yours,

T. KEITH GLENNAN, *Administrator.*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—RECOMMENDED CHANGES TO THE NASA ITEMS IN H.R. 7978 AS PASSED BY THE HOUSE JUNE 20, 1959

SALARIES AND EXPENSES

Recommended change No. 1

Page 3, line 14, strike out "$2,885,000" and insert in lieu thereof "$3,181,000".

Summary

The House arbitrarily cut approximately 10 percent from the NASA request for travel funds. The basis for this action was not reported.

The recommended change proposes full restoration to the amount requested in the President's budget. NASA's responsibilities are increasing significantly within the United States and in connection with worldwide tracking stations. Adequate travel funds are vital to carry out these responsibilities.

Recommended change No. 2

Page 3, line 17, strike out "$91,400,000" and insert in lieu thereof "$94,430,000".

Summary

The House arbitrarily denied salaries for 150 of the requested 1,027 new employees and cut by 10 percent the supporting expenses urgently required under the "Salaries and expenses" appropriation. The basis for these cuts was not reported.

The recommended change proposes full restoration to the amount approved in the President's budget. The additional employees are required to staff the Goddard Space Flight Center, the Wallops Island Station, and NASA headquarters where the impact of new duties and responsibilities is most urgently felt. The supporting expenses contribute primarily to the increased communication needs brought on by rapidly expanding international programs and tracking networks.

RESEARCH AND DEVELOPMENT

Recommended change No. 3

Page 3, between lines 18 and 19, insert the following provisions: "For an additional amount for 'Research and Development', as authorized by Public Law 86-12, $20,750,000, to remain available until expended."

Summary

The House deleted the entire item from the bill on a point of order. The item is for Project Mercury.

The recommended change proposes full restoration of the item as proposed in the President's budget with one modification, namely, the phrase "as authorized by Public Law 86–12" is added in place of the phrase "fiscal year 1959" for the purpose of technical clarification. Project Mercury, the Nation's manned space flight program, is the sole purpose for this item. A reduction of the funding level below that requested would adversely affect the program. This in turn would adversely affect the U.S. effort to achieve the first manned orbital space flight.

Recommended change No. 4

Page 3, line 21, after the word "equipment" insert ", and for other items of a capital nature as authorized by law,".

Summary

The House Committee on Appropriations eliminated the language without explanation.

The recommended change proposes restoration in identical form proposed in the President's appropriations request. The language is intended to clarify the effect of the provision in the fiscal year 1960 authorization act which allows the use of research and development appropriations for certain items of a capital nature which may be required for the performance of research and development contracts.

Recommended change No. 5

Page 3, line 24, after the word "Administration", insert ", including not to exceed $9,000 for representation allowance overseas and official entertainment expenses, to be expended upon the approval or authority of the Administrator;".

Summary

The House deleted the entire provision on a point of order.

The recommended change proposes restoration of the original language as proposed in the President's appropriations request. Over $7,000 of the $9,000 requested is required for representation allowances overseas in support of the NASA worldwide tracking network and data acquisition operations. An appropriation for official entertainment must be made expressly.

Recommended change No. 6

Page 3, line 25, strike out "thirty-two" and insert in lieu thereof "sixty five."

Summary

The House Committee on Appropriations arbitrarily cut the required number of new passenger-carrying vehicles by 50 percent. No basis for the cut was given.

The recommended change proposes full restoration of the original request. Of 65 required vehicles, 38 are to replace wornout or overage vehicles. The majority of the 27 new vehicles are needed for tracking station and data acquisition operations.

Recommended change No. 7

Page 4, line 1, strike out "nineteen" and insert in lieu thereof "thirty-eight".

Summary

The House Committee on Appropriations arbitrarily cut the required number of replacement passenger-carrying vehicles by 50 percent. No basis for this cut was reported.

The recommended change proposes full restoration of the original request. All of the vehicles meet the prescribed GSA replacement standards.

Recommended change No. 8

Page 4, line 2, strike out "$318,675,000" and insert in lieu thereof "$333,070,000".

Summary

The House Committee on Appropriations arbitrarily cut the total "Research and development" appropriation by 10 percent to $300 million. No basis for this cut was reported. The House restored $18,675,000 during the floor debate to partially compensate for the fiscal year 1959 supplemental item which was deleted on a point of order.

The recommended change proposes to restore the full amount approved in the President's budget. A reduction in research and development funds—which are the fundamental ingredients of this Nation's space effort—at the vary beginning of this complex program can only result in crippling our efforts to establish U.S. leadership in space.

Of the funds requested over two-thirds are already committed to continuing contractual obligations undertaken in fiscal year 1959. The major portion of the remaining third is needed to purchase payloads and meet other expenses incident to the efficient use of items already procured under existing contracts. Thus only a small, but highly significant, portion of the request has been earmarked for initiating new advanced research. A reduction of the total "Research and development" funds below the amount requested may lead to a serious imbalance of NASA's research program. Because a large proportion of the request represents fixed costs, which cannot be reduced without terminations or cutbacks, a reduction may seriously affect the amount of new research that can be undertaken. New research is the lifeblood of the U.S. continuing race for world leadership in space activities. Any reduction in the activity will reduce in geometrical progression the technical competence of the United States to undertake interplanetary flight programs.

Recommended change No. 9

Page 4, line 2 through line 8, strike out the proviso: and page 4, line 9, strike out the word "further".

Summary

The House inserted the language during the floor debate in substitution for other language proposed by the House Committee on Appropriations. The Appropriations Committee's language requiring specific prior approval of the legislative committees for items of a capital nature over $250,000 was deleted on a point of order.

The recommended change proposes to omit the House language, thereby restoring that of the President's appropriations request. The present language prevents any obligation of funds for the stated purposes for 14 days after the congressional legislative committees have been notified. The NASA feels that the notice provision contained in Public Law 86–45 is sufficient.

CONSTRUCTION AND EQUIPMENT

Recommended change No. 10

Page 4, between lines 12 and 13, insert the following provision: "For an additional amount for 'Construction and equipment', as authorized by Public Law 86–12, $24,250,000 to remain available until expended."

Summary

The House deleted the entire item on a point of order. The item covers additional facilities for the Jet Propulsion Laboratory, and additional tracking and propulsion development facilities.

The recommended change proposes the full restoration of the amount approved in the President's budget. The construction program submitted to Congress has two parts: first, those items essential to the discharge of the

new responsibilities of NASA in conducting the civilian space program and, second, those items required in the aeronautical and space research. If the recommended change is not made then either the new responsibilities, or aeronautical and space research, or both, must suffer. This will jeopardize the Nation's position in aeronautical and space activities.

Recommended change No. 11

Page 4, line 15, strike out "at Cleveland, Ohio".

Summary

The House Appropriations Committee inserted the language. No basis for the insertion was given.

The recommended change proposes to omit the language, thereby restoring the language to that of the President's appropriations request. Although the only land acquisition anticipated in fiscal year 1960 is at Cleveland, Ohio, the new language would prevent acquisition at other locations if required pursuant to any reprograming under the authority of the fiscal year 1960 authorization act.

Recommended change No. 12

Page 4, line 16, strike out $52,000,000" and insert in lieu thereof "$57,800,000."

Summary

The House Appropriations Committee arbitrarily cut the item by 10 percent. The basis for this action is stated as follows: "It is believed the NASA can make savings in the total program to the extent of the reduction."

The recommend change proposes full restoration of the amount approved in the President's budget. In addition to everything that was said in favor of the recommended change No. 10 the following must be added. The launching, tracking, and research facilities requested do not now exist, and a reduction in these funds will, therefore, imprudently curtail our national space and aeronautical capabilities in the immediate future.

Recommended change No. 13

Page 4, line 17 through line 23, strike out the proviso.

Summary

The House inserted a notice provision essentially similar to the one inserted in connection with the "Research and development" appropriation in recommended change No. 9.

The recommended change proposes to omit the language, thereby restoring that of the President's appropriations request. The present language prevents any obligation of funds for the stated purposes for 14 days after the congressional legislative committees have been notified. NASA feels that the notice provision contained in Public Law 86-45 is sufficient.

STATEMENT BY DR. T. KEITH GLENNAN, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION BEFORE THE SENATE APPROPRIATIONS COMMITTEE, JULY 13, 1959

Mr. Chairman and members of the committee, I welcome the opportunity to appear before this committee, for the first time. I am here to discuss H.R. 7978, which is now before you. In particular, I want to discuss the crippling reductions in the budget requests of the National Aeronautics and Space Administration that are embodied in H.R. 7978. These cuts, if sustained, would have disastrous consequences, and I am impelled to point them out.

The degree of success or failure of the U.S. space effort, vis-a-vis that of the Russians, will be gravely influenced by what Congress decides in this crucial matter.

A year ago this month, the Congress passed the National Aeronautics and Space Act: unanimously in the House, overwhelmingly in the Senate. One of the chief mandates laid down in the legislation was: "The preservation of the role of the United States as a leader in aeronautical and space science and technology * * *"

During later hearings on our fiscal 1959 budget request, some Members of Congress raised serious questions about our not having requested far greater sums than we felt, after careful study, that we needed to organize NASA and initiate its programs.

What has happened since then to give anyone a sense of complacency? For I can only interpret the action of the House as an indication of a lessening in the sense of urgency which has been expressed so often on the floor and in committee.

Have we—who started serious work in the space field 6 or 7 years after the Soviets were pouring unlimited funds and their best brains into the drive to dominance in space—suddenly achieved some enormous advantage?

If so, I would like to know about it. I would sleep better at night.

Or has it come about in some way that we know that the Soviet satellites and space probes, which our scientific devices have tracked and reported, were somehow gigantic hoaxes?

Gentlemen, tracking devices such as ours are not easily misled. We believe that the Russians have done exactly what they have announced they have done. And perhaps they have achieved much more that they have not revealed.

Wholesale expression of congressional support for NASA was evident until very recently. Today the situation is strangely changed. NASA is faced, not with having to decline a plethora of funds, but with the prospect that vital projects will have to be curtailed or even put on the shelf because funds for them are being denied.

I will not be challenged when I say that the United States must bend every effort to achieve a position of leadership in the space field. And we are all agreed that leadership in a race where there are only two participants cannot conceivably mean running second.

I do not have to tell you that we must have the facilities to exert that leadership. Also, we must have the men, we must have the money necessary to the task.

The goal all of us seek—U.S. supremacy in space—was set by Congress last year and reaffirmed this year when Congress authorized the full NASA budget request. This authorization reflected the awareness of Congress that we cannot win the race in which we are engaged during this turning point in history should we be deprived of the all-out support of our legislators.

Therefore, I request, with all the earnestness I can muster, that the cuts in the NASA budget be fully restored.

The reductions in the NASA budget total $68,225,000. They represent cuts both in the $45 million supplemental budget request for fiscal 1959 and from our $485,300,000 budget request for fiscal 1960. Actions in the House caused the reductions.

First, the House Committee on Appropriations cut the combined requests by a total of $45,500,000.

Second, technical points-of-order passed during debate in the House resulted in a further reduction of $22,725,000 in both requests.

I am urging the members of this committee to make full restoration because to sustain those cuts or to compromise them will hamstring the United States space program.

Moreover, if the Congress slices an already-lean NASA budget at a time when this Nation has barely begun its space effort, the world will conclude that the United States is having second thoughts about facing the Communist challenge in this field. Realistically, a research and development program of the complexity and magnitude of this one cannot be turned on and off at a moment's notice. Having made the decision to enter the race, and for many other important reasons, we must pursue with vigor an imaginative, well planned program.

Well aware of the implications of the Russian's commanding space lead, Congress created NASA last year around the nucleus of the highly respected National Advisory Committee for Aeronautics which had been serving the military services and the aircraft industry for 43 years. Our Agency became operative on October 1, 1958—1 year after Sputnik I began beeping ominously overhead. With NACA personnel and facilities, we were off to a good—if late—start.

From the outset, both Houses of Congress have given us the strongest possible support. House and Senate space committees have devoted many weeks of hearings to our problems and programs. The House Committee on Science and Astronautics has heard 300 witnesses from NASA, the military services, and private industry during 70 days of hearings so far this year. The Senate Committee on Aeronautical and Space Sciences has devoted a great amount of its busy schedule to NASA's program and the Nation's space effort. In connection with our 1960 budget the committee has published technical hearings of NASA work which are the most comprehensive, understandable, and edu-

cational documents on the Federal Government's aeronautical and space activities that exist today.

Both Houses of Congress have this year overwhelmingly approved the requested authorizations for our 1959 supplemental and fiscal 1960 appropriations. Consequently, I am unable to grasp the reasons for the House cut.

As Administrator, I have resisted the temptation to indulge in Sunday supplement speculation about the coming wonders of space exploration. I have been doing my utmost to see to it that the taxpayers' money is spent wisely as we venture into this new realm and reap its benefits. I have made it a point, however, to be explicit with the Congress about the inevitable costliness of space research. Repeatedly I have stressed during congressional hearings that NASA budgets will grow in the years ahead.

At the same time, I have tried to convey my deep conviction that space research holds the promise that it may soon be paying for itself many times over in tangible economic benefits. We have every right to count on developments in satellite meteorology, communications, navigation, and geodetics that will dramatically affect the lives of all of us.

Taking these considerations into account, last year we put together a budget for fiscal 1960 which we felt would get us well into space exploration. As has been said time and time again, inventions are not conceived on schedule, and vast sums of money, spent without adequate thought and planning, particularly in the early phases of a program, may hinder rather than facilitate projects.

Because space technology is an expensive, fluid affair, it requires continuous review. Since January, when the President submitted our fiscal 1960 budget request, we have found means to get considerable more space mileage per dollar in some areas than originally had seemed possible. We have also discovered that others of our programs will cost more than our original estimates.

When we prepared our first budget estimates back in November 1958, we based our space flight program upon Juno II and Thor-Able boosters. Our studies have taught us, however, that future reliance upon these vehicles would be uneconomical, in fact, that it is almost impossible to justify their use because of their limited load-carrying capacity and lack of versatility. We will, of course, use them for special-purpose tasks in connection with particular projects already under way. However, building on the technology developed out of the missile program, we have initiated development of Thor-Deltas, Vega, and Centaurs which—within 2 years—will enable us to launch much larger scientific payloads far more efficiently and cheaply.

This decision required that we pare our funds for basic research and for other activities. Subsequent studies have also indicated the need for additional tracking and data reduction installations and for the immediate modernization of existing stations. To meet this need, we have again had to trim elsewhere in the budget.

Adjustments like these are by no means unusual in a research program, particularly as we work at the frontiers of a new technology. We must deal with a new order of complexity and cost. We need to build and manage systems that are more than global in scope. Organization of the myriad components into a working whole is a staggering task.

At one and the same time, we find that advances of science generate a flood of new proposals and an unprecedented rate of obsolescence, thus making appraisal, selection, and phasing more and more difficult and complex. Direction and control of technology has become one of today's most pressing and managerial challenges.

As I brought out earlier, our present budget has no slack whatsoever. As further evidence of our tight belts, I would like to state that we do not have a single backup vehicle for any of our scientific experiments. Each must be a one-shot affair, and if the booster malfunctions, we will simply have to lay the experiment aside.

Before spelling out for you just what this cut will mean to our program, I would like to point out that our research centers, which are deeply involved in aeronautical as well as space research, account for slightly more than $100 million of our 1960 request. Actual new money for the space field is somewhat less than $375 million. Some or all of the large budget, long lead-time items in our space program, would be affected by the House action, if sustained. Here, in brief, is what the reduction could mean to our national space program in terms of time and progress:

(1) The development of the Vega rocket propulsion system might have to be drastically cut back. A key vehicle in our future plans, Vega will be capable of placing more than 5,000 pounds in an Earth orbit. It will be one of the first space vehicles capable of making extensive television surveys on the Moon's surface. It will also be used for communications satellite relay experiments and will have the capacity to launch two-man satellites. It will be our first which is capable of matching the payload lofting capability of the Soviets.

(2) In addition to cutting back Vega, we might have to retard Centaur, another key space vehicle which will be able to place more than 8,000 pounds in a 300-mile orbit and should be capable of softlanding a 730-pound scientific payload on the Moon. The Department of Defense, as well as NASA, has a strong interest in this vehicle.

(3) We would have to eliminate or drastically reduce the $30 million needed for the 1½-million-pound-thrust, single-chamber engine. This is a long lead-time project to provide in about 6 years time propulsion units capable of 6 million pounds thrust. Only with this vehicle will it be possible to carry our manned expeditions to the Moon and back. The budget cut will set this back at least 1 year.

(4) Among other long lead-time items on which we would have to reduce the pace is Project Rover which concerns the development of nuclear propulsion for space travel.

(5) We would have to delay completing additions to our tracking and data acquisition networks.

(6) Even our top-priority Project Mercury, the manned satellite project, would certainly be affected if we are to carry on with any semblance of a balanced program. This, of course, would increase the probability of the Soviets scoring still another beat in this aspect of space exploration.

Let me assure you that I am not crying wolf. While we have not had the time to evaluate in detail the effect of the proposed cuts, it is clear that the items enumerated would be those most likely to be affected.

A final, serious matter that I want to mention is the House action which reduced NASA's request for personnel increases and supporting costs. You will recall that when the National Advisory Committee for Aeronautics was absorbed by NASA, 7,699 employees were transferred to the new agency. Along with the transfer went NACA's heavy aeronautical research responsibilities. Since that time, only 1,269 employees have been added to carry the additional responsibilities.

Now, we have requested funds to employ an additional 1,027—a modest increase in view of NASA's mission. The House cut this number by 15 percent. These people are urgently needed to help make up the time that has already been lost. And the management—the sensible management—of a budget of the size under consideration is done by people in adequate numbers and of high quality. We have said that we propose to limit the size of our own staff in favor of contracting a substantial part of the space program. But we need men for planning, contracting, and monitoring those contracts. And we must have a sufficiently large in-house operation to assure that we have people knowledgeable in the field to provide the technical judgments necessary to the development of a sound program. Without the men to do the job, we will break our stride and fall even farther back.

The decision in this Nation's space exploration program is up to the Congress. Whatever the decision you make, we will attempt to carry it out with diligence and devoted effort.

The work we are now doing is an important instrument of international prestige. By utilizing their space exploits as an instrument of power politics, the Russians have convinced a large segment of world opinion that success or failure in these experiments is a valid measure of our scientific progress and general cultural status, as opposed to theirs. And there is no blinking the fact that the uncommitted nations are influenced by space achievement.

In conclusion I want to say that in my judgment, and in the judgment of the scientists and engineers who are with me here today, our 1959 supplemental and 1960 budgets as originally submitted are sound—and conservative. They cannot be reduced without placing in jeopardy some of our most important programs.

Mr. SISK. Let me emphasize one thing. I don't know what is going to happen this year on the budget, but I think it is your responsibility, Mr. Horner, and Dr. Glennan's, and others of the NASA, to get down

here and to tell this committee—and I hope my good friend from New York will agree with me—to tell this committee about anything that occurs in the appropriations or the authorization bill that is going to substantially delay any portion of this program.

I feel that it is imperative that you tell this committee when this occurs.

If you told this committee last year, at any time, that this was going to be slowed down to this extent, I personally was not aware of it. I don't know everything that goes on in this committee, I am sure. But I am saying to you now, Mr. Horner, as a matter of good procedure, I would hope you would see fit in the future to tell us about it.

As I say, I hope my good friend from New York agrees with this, because we have some responsibility in this thing, too.

Mr. HORNER. Mr. Sisk, we are very appreciative of the interest this committee has shown consistently in the integrity of our programs, and in its support. We will take every possible measure to see that this committee is kept informed.

Mr. RIEHLMAN. Mr. Chairman, last year, by the time we completed our activities here, it was pretty late in the session for us to be notified as to what the actual action by the Appropriations Committee was. I think we are going to be in a much better position this year if we move along so we can be conversant with what the Appropriations Committee does with respect to the authorization we passed, and I hope we do the job here necessary to support them.

I feel just exactly as my chairman does. We should be constantly abreast with what the actions are in respect to the Appropriations Committee, and how it is going to affect your program if we are going to be helpful to NASA in carrying out its activities.

Mr. HORNER. I can certainly commit the activities of the NASA to the extent of assuring you that we will indeed be happy to keep this committee informed of the progress of the authorization request and the appropriation.

I would like to respond to one other point you made, Mr. Sisk, and perhaps this is an error in judgment on our part as regards specifically the F–1 engine.

We found ourselves in a position, as you had mentioned earlier, of requiring the bulk of the unused authorization for Project Mercury.

We have asked for that appropriation in a supplemental appropriation. We faced the fact that in order to get any additional support for the F–1 engine in this time period, it would require new authorization. It was our judgment, and as I said, maybe it was not a good judgment, that we would have difficulty justifying a separate authorization procedure in the Government arrangements that have been established, specifically for this F–1 engine, with any reasonable expectation of getting relief for the F–1 engine any earlier than we could get it through the normal 1961 budget authorization and appropriation.

Having made that judgment, then the needs for the F–1 engine are reflected in the authorization request which you have before you at the present time.

Mr. SISK. I want to say to my colleague from New Mexico, if he has a question at any time, we are proceeding here in our subcommittee rather informally to try to develop as much backup information as we

can. I am sure the gentleman is aware that the area in which we are concerned at the present time is the liquid rocket engine.

So, if he has any questions at this time——

Mr. MORRIS. Mr. Chairman, I appreciate it. I think I will listen for the time being.

Mr. SISK. Let me conclude my part of this by just this last question.

Do you anticipate anywhere in the foreseeable future that you are going to be given a DX priority rating on the F–1 engine? It is my understanding this request has been made to the Security Council and to others, and so far they have refused—or the Space Council, rather—they refused to give this a DX rating.

I will put it in two questions. Do you think it should have a DX rating, and, second, do you think there is any likelihood it is going to get one?

Mr. HORNER. The question requires a rather complex answer, I am afraid, because of the way our priority system is arranged.

Substantively the only effect a DX priority rating has on any development project is to break the logjam of material shortages should they exist.

Mr. SISK. And personnel shortages, brainpower, doesn't it?

Mr. HORNER. Yes, sir, that is correct.

All of the work on the F–1 engine at this time is being carried out under contract with American industry. It is at the stage of development and will be for the next 2 years of treating very small numbers of engines in a comprehensive test program.

The contractor informs us he has no material shortages. The numbers of different kinds of items that he is buying, the amount of basic material he is buying, is such that he doesn't have any such problem, and, of course, his only problem with personnel is money to pay their salaries, and the DX priority would have no effect on that.

Now, it is not quite accurate that a DX priority has been requested from the Security Council.

Mr. SISK. That is the Space Council, not the Security Council, isn't it? The Space Council in this case would grant it?

Mr. HORNER. In the final analysis the Security Council passes on the highest national priority.

Mr. SISK. I was right in my first part of my question, then.

Mr. HORNER. We at one time did include the F–1 engine on a listing of projects which we felt warranted a DX priority. It was after a discussion of the priority system, and the projects with the Defense Department, that we came to the conclusion that we could not conscientiously support a request for DX priority on this development.

I think, Mr. Sisk, that it is accurate to say there is general misunderstanding concerning what the priority system is, and what effects it has, on development programs especially.

Mr. SISK. Let me ask you, What priority does Mercury have?

Mr. HORNER. Mercury has a DX priority because there are large elements of the Mercury program that are carried out within the Government. There are many, many agencies involved in Government that are contributing to Mercury. The DX priority has been very fruitful in the case of Mercury, because we have had to assert relationships between our own projects, our own space task group, and the Department of Defense, and various other Government labora-

tories that are working on the program, and in a sense it is a production program.

We do have, for example, in the Mercury program I think 12 Atlas boosters.

Mr. WYATT. Fifteen.

Mr. HORNER. Fifteen. The Atlas missile itself does have a DX priority rating. If we had no DX priority in the Mercury, if there was a conflict in the actual booster, the Atlas certainly would have complete claim on the boosters as opposed to the Mercury program.

We also have under contract I believe 24 capsules, I may want to change that number.

Mr. WYATT. I think that is right.

Mr. HORNER. This is a production problem, then. There is a materials requirement here. So for these reasons of both materials, equipment, and the personnel, the availability of Government personnel and Government laboratories, and other Government agencies, the DX priority is necessary and it is working for project Mercury, but this is quite a different project than the F–1 engine development at ths time.

Mr. SISK. All right, Mr. Horner.

Before we pass on from this section of the bill, I want to give our staff people an opportunity to question.

Ray, do you have some questions?

Mr. WILCOVE. Yes. Mr. Horner, with regard to the request for the DX priority on the big engine project.

The request was first made to the Department of Defense and was turned down. Now, as I understand your position, at this time NASA was convinced by the Department of Defense that the DX priority was not necessary. If that was so, why was the request then submitted to the Space Council?

Mr. HORNER. Mr. Wilcove, I am sorry, I will have to go back and check the record on that. As you probably know, I was not a member of the Administration at that time, and I would be afraid to rely on my memory. I don't know whether any of my associates here can specifically call out the order of events. It is not my understanding, however, that the request was submitted to the Space Council after our discussions with the Department of Defense. I will have to check that to be sure.

Mr. WILCOVE. Well, let's put it this way. The request was turned down first by the Defense Department and then by the Space Council. That is my understanding.

Mr. HORNER. I don't think that is correct, but I would like to fill out the record on that, if I may.

Mr. WILCOVE. I would be glad later to put the actual dates in the record.

Mr. SISK. Will you in answer to that be sure to fill out the record, because this is a rather important point?

Mr. HORNER. Yes, sir.

Mr. SISK. It is one which I had checked on a little bit myself. That is one of the things that led to my question. So somewhere here I think there is a little conflict.

(The information requested will be found on p. 348).

Mr. SISK. Go ahead, Ray.

Mr. WILCOVE. First, I would like to emphasize that when we are talking about a lack of funds for the F–1 engine, we are talking about $500,000 a month, a rather small amount for your overall budget for research and development.

Actually, you were appropriated $335 million. Of that amount, as I recall, $15 million was transferred to construction and equipment, which left $320 million.

Now, at the same time that you were cutting the F–1 program you were increasing some of your other programs, despite the cut in the research and development funds. I mean programs in addition to project Mercury.

It would appear to me, therefore, that while you considered other programs more important, you considered the F–1 engine less important.

Could you tell us what other programs were increased after the $18.5 million cut was made in your research and development funds?

Mr. HORNER. I will look at our program, Mr. Wilcove. I am not aware of any such increases. It is awfully hard to say increases from what, because our program plan, I think, was fairly well firm at the end of the last fiscal year of operations.

Mr. WILCOVE. Let us put it this way. You had your program all planned and you submitted it to the appropriations committee. It called for $335,350,000, in research and development funds.

Now, when you received a reduction in the amount appropriated below the amount authorized you felt you had to absorb, and undoubtedly you did have to absorb, the amount of the reduction. The big engine project took a $6 million reduction.

I have been informed by your own budget office that in the reshuffling of the program that followed, some of the programs, including apparently project Mercury, had their funds increased.

Mr. HORNER. This is certainly very possible, because, as these development programs go on, as I mentioned earlier, the support that an individual project demands is a function of where you happen to be on the progress in that project at the moment, and if you are very much in the hardware stage of development, and there is, for example, an overrun in the project which requires that more money be applied for specific hardware item completion, we might very well add small amounts of money to individual projects.

I don't have any such projects in mind. Perhaps Mr. Wyatt could answer.

Mr. WYATT. Yes, I could respond to some of the things that occurred. They all bear on and supplement the testimony that Mr. Horner has given.

We had underway specific projects which we outlined to the Congress last year in these areas of scientific investigations in space and satellite applications, as well as project Mercury. These were our flight program areas.

Now, we have to go back to the perspective that the 1960 budget was prepared within 2 months after the NASA became an agency, and many of our estimates, particularly on Project Mercury, of our anticipated necessary 1960 expenditures, were at a very, very early state, before the projects really got underway. The same considerations held for many of the other flight projects; scientific satellites, lunar and planetary exploration problems, and so forth.

We did find it necessary, first off, to considerably augment the amount of money in Project Mercury in order to try to maintain the fastest possible rate of development for Project Mercury. We did this by reprograming some of the 1959 funds, to the extent of about $8¾ million, and we applied this to Project Mercury.

This meant that for projects which originally we had anticipated funding from 1959 in other areas, we had to remove the money, and this prevented us from making as much of a cut on the surface in these projects in 1960 as we otherwise might have.

Then in Project Mercury in addition, as you remarked, we found it necessary to transfer $15 million to the construction and equipment account in order to get on with the construction of the tracking range. So that we had to absorb this $15 million on top of the $18 million reduction in the appropriation, so really we were facing the year with a $33½ million net cut below what we had hoped were going to be our resources; $18½ of it because of reduction in appropriations, and $15 million of it because of a realization that we were going to have to apply money more rapidly to the Mercury range than we had anticipated.

Well, as you look at the whole program, as you consider the development items that were underway, that as Mr. Horner has pointed out have to precede the flight of a Nova vehicle, or any other vehicle to the moon, we felt that we had certain items that we could not reduce. For example, the Centaur engine development, we did not reduce that.

At that time the Vega vehicle development was not reduced. Later on those moneys were reprogramed when the Vega project was canceled. We did reprogram some of those moneys into an apparent increase, for example, in the lunar and planetary exploration account. But you must bear in mind that when Vega was a going project, the Vega vehicle development account provided the vehicles for some of these lunar flights. When we canceled Vega, and chose to use the Agena as the vehicle, we had to move the funding up into the Lunar and planetary account to pay for the Agena vehicle. Hence, what we were doing was substituting an Agena vehicle, or a number of them, for Vega vehicles. We moved the money up but did not actually increase the scope of the lunar and planetary program, but by a simple change in bookkeeping we then showed the money under the program to be applied to the vehicles, whereas previously the vehicles were provided from a development account.

We had to make a number of adjustments such as this, but simultaneously we actually did have to make very careful examination of our whole flight program, and, as Mr. Horner has already pointed out, we cut the meteorological program to the slowest rate that we felt made any sense to carry on. We had to stretch out and reduce the rates of firings on the scientific satellites, and the lunar and planetary areas in order to accommodate the effective $33½-million reduction in resources because of the uncommon demand of the Mercury project.

Mr. WILCOVE. Well, now, I am not being critical of the reshuffling of the program, and the fact that some of the programs had their funds increased, but I am concerned that in the reshuffling the big engine project was delayed 12 or 18 months because of a loss of $6 million.

Let me ask you this. Was there any program other than F–1 which received a cut of $6 million or more?

To phrase it another way, did the F–1 engine receive the largest cut?

Mr. WYATT. When we presented our 1960 budget in the manned space flight area we presented an item of $20 million for a program to follow beyond Project Mercury. We had to wipe that out completely, although we did not change moneys in the account. We actually reduced the manned space program by $20 million. What we did was wipe out the followup effort and applied that money directly to Project Mercury.

This is one example where we did change the program.

Mr. WILCOVE. Was any program cut more than the F–1 project?

Mr. WYATT. The manned space program was cut $20 million in terms of the followon effort.

Mr. WILCOVE. But the program itself, the immediate program, you did not cut it?

Mr. WYATT. No, sir; we held the Project Mercury.

Mr. WILCOVE. Timewise, you didn't delay the program?

Mr. WYATT. Not Project Mercury.

Mr. WILCOVE. Was there any other program besides the F–1 that was cut that much?

Mr. HORNER. The Centaur was cut by an almost comparable amount. I don't know whether it was that much.

Mr. WYATT. $4 million.

Mr. WILCOVE. About $4 million?

Mr. WYATT. I don't recall these numbers specifically. We would have to examine that.

Mr. SISK. Just a moment. Let me ask you a question there.

Where did you get the $52 million turned over yesterday to the Air Force?

Mr. HORNER. I beg your pardon?

Mr. SISK. You just turned over $52 million to the Air Force.

Mr. HORNER. That is from the research and development program account.

Mr. SISK. You turned that over when, now, just the last few days?

Mr. HORNER. We turned it over to the Air Force because we are using them as our contracting agent in the Centaur program. It shows on the books as being turned over to the Air Force. Actually, the program is under our technical supervision.

Mr. SISK. In taking a look at the figures, I was curious where you got the $52 million.

Mr. HORNER. Out of Centaur and Mercury, I believe, almost wholly out of those two accounts.

Mr. SISK. Out of Centaur and Mercury. All right, Centaur had $37 million in it, and Mercury you stepped up. You have not cut it back, so I was still just a little bit curious. He is worrying about $6 million and I noticed in this morning's newspapers that $52 million was turned over to the Air Force.

Mr. WYATT. This is simply a channel by which we are expending that money. In the case of the McDonald contract, this is transferred over to the Defense Department because they are our fiscal agents, they are our contracting agents. But that is part of the programing of these funds. It does not represent an addition to anything that we have programed here.

Mr. HORNER. I would very much like to assure the committee that we regret the stretchout, the decrease in funds on the F–1 engine just as much as the committee does. We would like to carry this program at the rate at which it was originally planned. We certainly, if we possibly could, would find other places to accept that decrease. It is our judgment that should we—had we applied that $6-million decrease to any other area, the committee would have found it even less palatable than to the F–1 engine. We feel it would have made less sense in our program and caused us problems in the balance of the program.

Mr. SISK. Go ahead.

Mr. WILCOVE. Mr. Chairman.

Will you submit for the record a statement showing how the cut of $18.5 million in research and development funds was absorbed by your program?

Mr. HORNER. We would be glad to.

(The information will be found on p. 377).

Mr. WILCOVE. I have one more question.

I believe, Mr. Horner, you said with regard to a manned expedition to the moon in this decade—I don't know if I am quoting you exactly—but I believe you said that if you had unlimited funds it was quite possible that a manned expedition could reach the moon this decade. If that is correct, could you submit to this committee a statement of how much funds you think would be necessary to achieve such a result?

Mr. HORNER. We will try.

Mr. WILCOVE. Thank you.

Mr. HORNER. This requires a tremendous amount of analytical study, Mr. Wilcove, in order to provide a sensible statement in that respect.

Mr. RIEHLMAN. Mr. Chairman.

Mr. SISK. Yes.

Mr. RIEHLMAN I wonder if Mr. Wilcove couldn't modify that? I don't want to put a burden on NASA to go back into research here for weeks to give us an exact figure. I think if they come up with some rough estimate, that is all the committee would like.

Mr. WILCOVE. Yes, I think an approximation would be all right.

Mr. SISK. The point I think of the question, as I understand it—and, of course, this leads to a large extent to the fact that I took as much time as I did this morning after I analyzed and did some thinking over the weekend about the whole direction here, and that is that apparently NASA today, even though this is 1960, has conceded in their own opinion that there is no possible chance of a manned expedition and return from the moon in this decade. That is a summation of your statement, certainly for Thursday, isn't that true, so we can just sum up on that basis?

Mr. HORNER. A manned space flight to the moon certainly will not occur in this decade unless we plan it, so we have not planned it so it will not occur in this decade.

Mr. WILCOVE. Can we amend that to say it will not be done by this country?

Mr. HORNER. This is not saying the program cannot be changed.

Mr. WILCOVE. Or other countries cannot achieve the same results?

Mr. HORNER. I am sorry. I was referring to the United States.

Mr. SISK. The change of the program, I think, was the main point of Mr. Wilcove's question. I realize it probably would take a lot to pin that down to anything other than opinion, but that goes to the whole problem. I am going to ask the chairman of our full committee to have the rocket people come in and give us their picture on what is happening to the F–1 engine and what they think about it. That, of course, is going to be up to him, and the committee. But I hope we can explore something further on this.

Are there any other questions before we leave this part?

Mr. HINES. I would like to address my question to Mr. Hyatt, and refer to a previous question about the solid-fuel rocket development that is being accomplished by the Air Force.

Does NASA intend to participate in this particular program or a similar program?

Mr. HYATT. In this particular one you are referring to, the program that Mr. Horner discussed last Friday?

Mr. HINES. Yes.

Mr. HYATT. We are participating in the sense we have had people on the evaluation team. We do not plan to supply any funds to them for this program.

Mr. HINES. You do not?

Mr. HYATT. No.

Mr. HINES. Is the art sufficiently developed, or does the technical philosophy under which NASA is operating now to utilize a million-pound boost permit the utilization of say, a 20 million seconds of specific impulse?

Would you have to redesign your components?

Mr. HYATT. Could you restate your question? I am not sure I can address myself to the question as stated.

Mr. HINES. As I recall the testimony of Thursday, you said the Air Force solid-fuel development program plans a specific impulse of 20 million seconds. This would imply a booster of tremendous acceleration, getting off the ground very rapidly, which would certainly impose a tremendous technical problem to build components to withstand such loads.

Is this too great a departure from your present philosophy?

Mr. HYATT. This is not so. Twenty million pounds can be divided up as Mr. Horner stated into 250,000 pounds of thrust for, say, 80 seconds, or it could be a million pounds of thrust for 20 seconds. You multiply the two to get the pound-second impulse.

Mr. HINES. Yes.

Mr. HYATT. Now, if you had a 250,000-pound-thrust engine, and you had a weight of 200,000 pounds, then the acceleration would not be as great as you implied.

Mr. HINES. One other question with reference to the F–1 engine, which I hope is the final question on this: The Navy has said that their Manhattan-type approach to the development of the Polaris was very successful. I realize the Navy has large resources to draw upon, but would the creation of a Manhattan-type project or approach to the F–1 engine development materially accelerate that program?

Mr. HYATT. I don't think so, because when we speak of a Manhattan-type project, or a project similar to Polaris, we are speaking of a systems project, where we have engines, we have vehicles, we have submarines, we have training, we have all sorts of things that go into the entire weapon systems.

In the case of the F–1 engines, there is just one component of a complete system, and that is handled entirely in one industrial company.

Mr. HINES. Perhaps I was too narrow in my question. I was envisioning the followup of the F–1. I should have mentioned this.

Mr. HYATT. If you intend to say the entire Nova configuration, and the plan to use it, let's say, for a manned expedition to the Moon.

Mr. HINES. That is what I was leading to.

Mr. HYATT. If this is your question, then certainly a single organization devoted to just that goal, in my personal opinion, is more efficient than having an organization take care of it that has other goals in mind.

Mr. HINES. Let us assume this is established, or this is deemed to be proper. How would this approach to the F–1 development inhibit the other programs of NASA? Would this provide a serious drain upon other programs, in talent, and money?

Mr. HYATT. Again, could you be more explicit?

Mr. HINES. Well, you have programed your procedures for the F–1 engine to produce an engine of million-pound thrust and the Nova configuration, all within the framework of NASA's current programs. You inserted a change of organization, we will say, and established the Manhattan-type project. Would this inhibit or seriously affect the progress of the other NASA programs in conjunction with this?

Mr. HYATT. Well, it would in the sense that probably Congress would divide up the funds and make lesser amounts available to NASA, so it would definitely have an effect on other programs.

Mr. HINES. I am thinking more in terms of other resources, to—talent, for one. A Manhattan-type approach implies the ability to go right into any program and take what is needed from other programs?

Mr. HYATT. Yes.

Mr. HINES. This would happen, would it not?

Mr. HYATT. I think, sir, you answered your own question. The Manhattan-type program, with its top priority and so on, the answer would be yes.

Mr. HINES. Thank you.

Mr. SISK. All right, are there any other questions on this liquid rocket?

I think we have pretty well hammered this one around. We have got at least some idea of the thinking of NASA and whether we are happy with it, or not, at least we know pretty well what you expect to do.

With one final closing question, then, we will move on. In your opinion, the $63 million that is requested for the liquid rocket engines for 1961 will be ample to permit a maximum rate of development. Is that right?

Mr. HORNER. Yes, sir; from the area—from the program level at which we are today, I think it would be better to say that it will provide for a very energetic level of development of the F–1 engine. I hesitate to say maximum.

Mr. SISK. Well, of course, that is the thing that gets on my nerves a little bit, this hedging around on the terms, when I think we should be moving ahead at the maximum rate of development. That is not a criticism of your terminology, because I realize you are under the gun.

Mr. HORNER. The answer to your question, then, Mr. Sisk, is no, it is not enough.

Mr. SISK. I expect to explore this thing further in the future.

The next item is nuclear systems technology, which we decided to carry over until later.

The next item is space power technology, on page 181. I believe we decided, as I recall, that it would be well to have the AEC people testify before considering it and lump those two together.

Was that your recommendation, Mr. Horner?

Mr. HORNER. Mr. Sisk, I felt there might have been some confusion on that last Thursday. Actually, this is power technology unrelated to nuclear sources. There is no reason why we shouldn't go ahead with this at this time.

Mr. SISK. Fine. You go ahead and explain if you can briefly what you have in mind on this space power technology here. You are requesting $8 million. That is about double what you had last year. Right?

Mr. HORNER. Yes, sir. And I would like to have Mr. Finger talk on that.

Mr. SISK. All right, Mr. Finger, fine. We haven't heard from you in these hearings, so we will be glad to hear from you for a while.

Mr. FINGER. It has been interesting listening.

STATEMENT OF HAROLD B. FINGER, CHIEF, NUCLEAR PROPULSION, OFFICE OF LAUNCH VEHICLE PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

This space power technology program is actually divided into two areas. One is the development of the technology and development of systems for producing electrical power in space other than those systems that use nuclear power sources. The other part of the program is the development of electrical thrust devices that would be tied to nuclear electric systems to give us electrical propulsion rockets.

So we have electrical thrust devices and electric power generating systems other than the nuclear systems in this program.

Let me, first discuss the electric power generating systems other than those dependent on nuclear sources. As you know, in practically all of our satellites to date, we have used chemical systems (batteries to produce electrical power) or solar systems (large silicon cell arrays) which had silicon cells arranged on arms, and when the payload was boosted into the orbit, these arms sprung out and started generating power due to the action of solar radiation on these silicon cells.

We find in addition that there are other ways of using solar power. For example, we can use a very large mirror and focus the rays of the sun on a boiler and boil a working fluid which drives the turbine as in our ground systems. This turbo-generator system is then adapted to the solar system. All of these systems are covered by this budget item.

I would like to address myself here to the line items that appear on page 182.

The first two items are those applicable to the generation of electrical power. The first is the Applied Research and Development item. This includes many different pieces of the electric generating system. For example, in this applied research and development item are funds for the reduction of weight of these large silicon cell arrays. It turns out the weight of these arrays is determined by the structural weight of the system. The silicon cells, themselves, are very thin and very light, but we must mount these silicon cells on to some sort of a plate. Since these arrays become extremely large, this plate must be a heavy structure just to support itself during the launch.

There are, we believe, ways of reducing the weight of these arms. Research and development aimed at reduction in weight of silicon cell arrays is then included in this item.

In addition, in all of these solar devices, solar powered electric generating systems, there are times when we operate in the dark; that is, as the satellite moves around the Earth it gets into the dark side of the Earth at times. Since there is no Sun, if we didn't have some auxiliary device for storing power, we would have no electrical power during this time. We must use, then, various kinds of storage systems.

For example, we can use storage batteries, and in many of our systems that is exactly what we do. The Explorer VI has storage batteries.

When we go to more advanced systems, for instance the large solar collector systems, the temperature is too high, and the life of the batteries are too low to permit effective application of these to solar collector systems. So we have to develop new ways of storing solar energy while the payload is on the dark side of its orbit.

One of these systems is to melt a metal, and then use this molten metal—it is a hot molten metal—to heat fluid and drive this turbine while we are on the dark side.

This requires research and development in order to determine how to contain the fluid, how to draw heat out of it when we need it, and so on.

There are other methods also of generating power, and storing power in fuel cells, in which, for example, hydrogen and oxygen can be stored and used to generate electrical power.

All of these items are included under Applied Research and Development. This work will be conducted on contract and in addition a large part of this work, particularly the silicon cell array work, will be handled by the Jet Propulsion Research Laboratory.

Now, the second item is the Development of Solar Auxiliary Power Units, and specifically the kind of a unit we are talking about here is this large solar collector system that focuses heat on the boiler and drives the turbo-generator.

The unit that we have already invited proposals for would generate three kilowatts of electrical power, and could be used with the Centaur and Saturn vehicles. It is a long-life electric power system. These funds cover the development of that system, and associated auxiliary equipment.

For example, there is another problem in these systems, and that is that the collector must always be aimed at the sun very accurately to get high temperature, so that, included in the solar unit development, is an attitude control system specifically for that unit; a system which will accurately control the collector's attitude so that it faces the sun.

In addition, the heat storage system, for this particular unit is in this budget item. Basically, this is a development project, a development of particular hardware; the first item being research and development to develop improved methods of generating power.

Now, the next main area of our work is directed at research and development on electric thrust generators. The first two items in the budget are the electric power generating systems, the second two are the electric thrust generators, and there are a host of different kinds of electric thrust devices. In fact, there are so many that it is too early to pick any one and say this one will carry us through all the missions for which these systems are advantageous.

As you may recall in our presentations before the full committee, we indicated that these electric rockets, of which the electric thrust generator is the thrust producing portion, are considered to have very high potential for accomplishing long-range missions.

If we talk about a logical development program, we would first use these on near-earth missions. For example, we might use them to raise a satellite from a 300-mile orbit to the 24-hour orbit. And it turns out for missions of that sort, or for planetary probe missions, we don't need as high a specific impulse, or as high a value of pounds of thrust per pound of propellant expended, as we would like in very long-range missions.

In fact, we can get by with something like 2,000 seconds of impulse, and for that reason, we are doing research and development on these plasma arc jet rocket engines.

Specifically this is a system in which hydrogen, or helium, or other gases are heated by the use of an electric arc blown across the jet. Then, this hot hydrogen is expanded through a regular jet nozzle.

These systems appear capable of developing up to 2,000 seconds impulse, and you can see we have this third budget line item which is aimed at the development of the plasma arc jet rocket engine, and also at research on plasma arc jet rocket engines. Hopefully this would result in a plasma jet that could be tied to our SNAP–8 system, which we will discuss after the AEC appears before the committee.

The SNAP–8 is covered in our nuclear systems. The final item is the ion rocket engine. This system is capable of developing impulses up to 10,000 and 20,000 seconds, and it, I believe, is the system that looks best for very long-range missions.

The importance of impulse is that the more thrust you can get out of every pound of propellant flowing out of the jet nozzle per second, the less the total propellant you need. For very long-range missions, the saving in propellant is a very significant factor and lets us deliver higher payloads.

There is more room left for payload if we use less propellant. So the final budget line item then is research and development for ion rocket engines. Again it would be hoped some work applicable to a system of SNAP–8's, or clusters of SNAP–8's would arise out of this, but this item is research and development work.

I think this covers all of the items. I might just make one other statement, and that is that with these electric thrust devices, we would certainly want to use nuclear power systems. The nuclear power systems for generating electrical power needed is included in our nuclear systems technology budget.

All our nuclear work appears in that budget item. Thank you.

Mr. SISK. The gentleman from New York, do you have any questions?

Mr. RIEHLMAN. That is a very interesting statement, Mr. Chairman, but I don't feel I want to ask any questions.

Mr. SISK. The gentleman from New Mexico?

Mr. MORRIS. Mr. Chairman, I would just like to ask the gentleman one question.

Would a large solar furnace be an asset to the basic research in the solar auxiliary power unit?

Mr. FINGER. You mean the ground type system?

Mr. MORRIS. Yes.

Mr. FINGER. It might. I think one of the main problems is that none of the ordinary solar furnaces I know of, these large reflectors, go to sufficiently high temperature to be really useful.

There are other ways of mocking up the heat. That is, for development of most of the auxiliary components, we can mock up the heat.

Mr. MORRIS. Yes, you can mock up the heat, but you don't get a pure heat, do you, by these other systems?

Mr. FINGER. It is satisfactory. The important thing is to get the temperature in the development of the auxiliary components, and that we can get in many ways. It is sufficient heat level that is required.

Of course, I am sure you have all seen these solar collectors that are being sold as barbecue units to fry frankfurters and so on. But obviously they don't go to 1,000° to 2,000° Fahrenheit which is what we want.

Mr. WYATT. Mr. Morris, if I may elaborate on this. I think you are referring to the use of the solar furnace in a metallurgical process for melting materials where it is desirable to have a very pure heat source so you don't contaminate the material, itself.

As such, the ground solar unit has a very definite place. In the applications we are referring to here, we are not trying to melt something and use it as a specimen; all we are trying to do is to boil a liquid within a container, so all we are interested in is applying sufficient heat to the surface of the container to get this heated, and the question of when you are mocking this up or working with it on the ground, the only problem is getting a comparable amount of heat focused on the container and you don't really care whether it is contaminated, say, due to the combustion of gases or not, because we are not concerned with the purity of the heat source.

Mr. MORRIS. But actually, isn't the only way to get a high temperature, pure heat, with the large solar furnace?

Mr. WYATT. I think you are correct.

Mr. MORRIS. Wouldn't it be very useful in research?

Mr. HORNER. The main difference here, Mr. Morris, is the level of heating.

Mr. Finger was speaking of high temperatures in terms of what is ordinarily available in backyard solar furnaces, but as a practical matter for the use in which he is concerned, temperatures on the order of 1,000° are adequate, whereas the very large solar furnaces that are used for metallurgical research are trying for temperatures of 5,000°.

Mr. MORRIS. Yes, that is correct.

Well, now, the National Aeronautics and Space Administration is interested in sending a man to the Moon, isn't it? That is one of the things we have been discussing here, is it not?

Mr. HORNER. Yes, sir.

Mr. MORRIS. Aren't you going to encounter some temperatures, possibly around 4,000° and 5,000° at times, when you go to bring this man back, or when you take him there, and isn't that going to be a pure heat?

Mr. HORNER. Temperatures from solar radiation, as far as spacecraft design is concerned, are relatively easily controllable by controlling reradiation. The materials problems that we encounter that are coupled with high temperatures, are almost without exception related to reentry into the atmosphere.

This is a temperature of compression of the atmosphere, and as such, is not uncontaminated in the sense that you mention it.

In fact, it is very much contaminated by the characteristics of the atmosphere.

Mr. MORRIS. Well, have you developed this?

Mr. HORNER. Yes, sir. As a matter of fact, we have in this current year's budget a facility at the Langley Research Center, the basic purpose of which is to reproduce not only the temperature, but the characteristic atmosphere also.

Mr. MORRIS. At what temperature?

Mr. HYATT. Mr. Chairman, just for the record, I would like to mention in the space propulsion funds, applied research and development, we also have funds for applied research and development on means of converting heat energy to electrical energy by other than turbo-machinery. These systems are called thermionic systems and thermoelectric systems.

Mr. HORNER. I am afraid Mr. Morris' question was interrupted.

The answer to your question is, the design objective is 5,000°. The temperature is applied by electrical boosting, electrically boosting the heat of the gas flow from a pebble bed heater.

Mr. FINGER. Your point is well taken. That system has a limited time of operation.

Mr. MORRIS. That is an almost instantaneous application, isn't it, to that type of device?

Mr. HORNER. I beg your pardon?

Mr. MORRIS. Isn't that an almost instantaneous situation?

In other words, you couldn't keep that 4,000° or 5,000° temperature for any length of time through that type of device, could you?

Mr. WYATT. It is anticipated, sir, in the description of the particular facility on page 309, they expect the running time of about 20 seconds at temperatures of 4,500° Rankine, or about 4,000° Fahrenheit.

There will be another leg in the same facility, and I have to read it from here because I am not intimately familiar with the particular facility. They are talking about temperatures of 7,000° to 16,000°, at running time of 3 to 4 minutes.

Mr. MORRIS. Are those processes already developed?

Mr. HORNER. The heating processes are highly developed in other facilities that we are now using. They have not been used to this degree, and this is an extension of the art. This is a very common technique in hypersonic aerodynamics.

Mr. WYATT. I would point out, sir, if a facility such as this produces not only heat, but also the velocity condition, for the condition of simulation which is very important—for example, in a nose cone as we know it now, an ablating type nose cone, in which you actually melt or ablate the surface as you re-enter, the flow pattern is determined by the velocity across the face as well as the temperature itself. And a facility such as the type on page 309 produces the velocity condition.

Mr. MORRIS. Mr. Chairman, that is all. Thank you.

Mr. SISK. Dick.

Mr. HINES. In 1958, Dr. Merkle described for us a propulsion device called "Old Pokey." Is that included within this budget section on which we are questioning you?

Mr. FINGER. No, it is not.

Mr. HINES. I won't question you about this then.

Mr. FINGER. The area he was talking about was in the nuclear rocket.

Mr. HINES. This is in another section?

Mr. FINGER. Yes.

Mr. SISK. We will move on.

In view of the fact that there are no requests for funds, will you briefly indicate the situation on Scout?

Mr. HORNER. The Scout program for purposes of development has been completely funded in fiscal years 1959 and 1960.

There is money in this budget to the extent of, I believe, $31½ million for the purchase of Scout, Scout vehicles for the scientific satellite program.

Mr. SISK. But then as far as Research and development——

Mr. HORNER. As far as Research and development, it has been completed, or will be completed within 6 months.

Mr. SISK. All right, fine.

Mr. WILCOVE. The overall cost of the Scout program would then be $6 million, $12 million, roughly $16 million. Is that correct?

Mr. WYATT. No, sir. The development cost is as indicated here, about $9 million.

The other figure that Mr. Horner referred to is for follow-on use items. In other words, the rate of $500,000 to $700,000 per vehicle, as we use them in flight programs. It has nothing to do with the development of the vehicle.

Mr. WILCOVE. What would you say would be the overall cost of the program then?

Mr. WYATT. We actually anticipate the Scout program going on for years. We will be using Scout in our program as far down the future as we can see at the present time.

Mr. WILCOVE. Over the years 1959, 1960, 1961, what would be the cost?

Mr. WYATT. $9 million development for the first vehicles.

Mr. HORNER. About $700,000 for each vehicle that would fly thereafter in any of the programs?

Mr. WILCOVE. That is all, Mr. Chairman.

Mr. SISK. Any other questions on Scout?

We will quickly take up Delta. Would one of you gentlemen comment on the Delta program? Your request is down just slightly from 1960, although approximately the same amount.

In fact, this seems to have been very fixed over 1959, 1960, and 1961.

Mr. HORNER. The reason for this, Mr. Sisk, is that the Delta program is a development program based on known components for the three stages of the vehicles to produce 12 vehicles which will have a better capability than the space vehicles that have been used thus far using the IRBMs as a first stage.

This vehicle takes the Thor as the first stage, a second stage from the Vanguard program, and a third stage from the solid propellent stage of the Vanguard program. This you will recognize is very similar to the Thor-Able configuration we have used previously in our program and that the Air Force has used.

The primary difference between this vehicle and the Thor-Able is the arrangement of the guidance system which permits a coasting period, which in turn will provide a more accurate performance and a better payload performance.

The $38 million here represents the total cost, not only for those developments related to the vehicle, but also for buying and launching the 12 vehicles.

Mr. SISK. Do I understand then that this actually will conclude research and development requests? That is, you anticipate this will terminate the research and development request for the program?

Mr. HORNER. Yes, sir; it does more than that, Mr. Sisk. It buys out the program to the extent we are going to use it.

The further vehicle procurement based on IRBM first stages will use the Thor-Agena which is a stage being developed now, and which we will use in other areas of our program.

Mr. RIEHLMAN. No questions, Mr. Chairman.

Mr. WILCOVE. Mr. Chairman.

Mr. SISK. Mr. Wilcove has some questions.

Mr. WILCOVE. What company is producing the Delta?

Mr. HORNER. The first stage is being produced by Douglas. The second stage is being produced by Aero-Jet General, and the top stage is Allegheny Ballistics.

Mr. WILCOVE. When will the vehicle be in operation?

Mr. HORNER. Its first flight is scheduled in April, I believe.

Mr. WILCOVE. April of this year?

Mr. HORNER. Yes; the month after next.

Mr. WILCOVE. Thank you.

Mr. SISK. The first flight is scheduled in April.

By the way, how many flights of the Delta are scheduled for this calendar year? Do you have any idea?

Mr. HORNER. I think it is five, Mr. Chairman, but I would like to correct that figure later if it is incorrect.

Mr. HINES. What is the intended objective of the April shot?

Mr. HORNER. I would like to provide that for you in executive session if I could, please.

Mr. HINES. All right.

Mr. SISK. All right. The total request here to close this program out, to buy it out, is $12½ million.

If there are no further questions, it is now 12 o'clock.

Off the record for just a moment now.

(Discussion off the record.)

Mr. SISK. We will plan on meeting tomorrow afternoon and you will be advised, Mr. Horner, you and your people, where we will meet.

I think there might be a few questions on Vega. Of course, it has been canceled now. There is no money request, but we will start with that tomorrow afternoon.

Thank you gentlemen very much. The committee stands adjourned.

(Whereupon, at 12:03 p.m., the subcommittee was adjourned, to reconvene at 2:30 p.m., Tuesday, February 23, 1960.)

1961 NASA AUTHORIZATION

TUESDAY, FEBRUARY 23, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE No. 4,
Washington, D.C.

The subcommittee met at 2:30 p.m., Hon. B. F. Sisk, chairman of the subcommittee, presiding.

Mr. SISK. The subcommittee will come to order for further consideration of NASA's budget requests.

I believe in our last hearing we completed the discussion on the Delta vehicle. I believe that is where we cut off. Am I right or wrong?

Mr. WYATT. That is correct.

Mr. SISK. Are there any further questions on the Delta before we leave that? I think we pretty well finished our discussions and are ready to take up the Vega.

Mr. GLEASON. Page 189.

Mr. SISK. All right. You have no request, Mr. Horner, for Vega. Of course, we understand that program has been canceled.

Are there any questions on the cancellation of Vega that anyone would like to ask for further clarification from these people?

I will ask one question. What was the total expenditure on Vega up to the time of cancellation?

Mr. HORNER. We had a total obligation, Mr. Sisk, a cancellation of approximately $17 million, plus a couple hundred thousand. Of that obligation, $7 million was obligated to Convair and about $5½ million was obligated to General Electric for the engine.

Most of the balance was to the Jet Propulsion Laboratory. We, of course, have started contract termination proceedings, and we will recoup some of that money. How much it is difficult to say at this time. I can assure you that it will be in excess of a million dollars, and it might be quite a bit in excess of a million dollars, but it depends upon the final audit and the final contract termination negotiation.

Mr. SISK. You mean we probably will not be able to recoup more than, say, a million or a couple million dollars out of $17 million?

Mr. HORNER. No, sir. The reason I——

Mr. SISK. I just want to be clear in my own mind as to what you are saying.

Mr. HORNER. The reason I mention a million dollars is that is the amount we have already been advised by the procurement authorities who are handling this program may be deobligated. In other words, we can now feel free to use that money for other purposes. This is

a process which is always conservative because, of course, the procurement authorities who are doing the termination negotiation must reserve enough money to cover any contingencies.

There will, I am sure, be some recovery above that figure. It is quite speculative to say how much at this time.

Mr. SISK. Well, actually, I was just trying to get a comparison here on the amount of money that had been spent in 1959 and 1960 on the Vega, as compared to some of these others. You actually asked for more money for Vega in 1959 than you had for the Delta. I believe that is right.

Well, I think, so far as that goes, you pretty well discuss the reasons. I suppose it is one of those questions which it is a little difficult to determine. Some of that, of course, in addition to this so-called direct recovery is—Did I not understand from our posture hearings that some of that will be recoverable from the standpoint of some usefulness and the R. & D. research, and so on, which will be applicable to other programs?

Mr. HORNER. There is a very large payoff, in the sense of technological advance, that has been made in the Vega program, which will be useful to other programs. For example, a large percentage of the money at the Jet Propulsion Laboratory was being invested in the development of a storable fuels top-stage engine for the Vega. We are carrying on this development as a desirable capability in space propulsion. So in a sense the money that was invested in that engine is now a part of our program that is no longer chargeable to Vega, of course.

There is also another indirect payoff in that the Vega upper stage was being engineered by Convair, which also has the engineering responsibility for Centaur. Many of the developments—much of the development activity that was being carried out at Convair does have an interconnection with the Centaur work in the same company, and the Centaur was benefited from that work.

Mr. SISK. Let us move on, then, Mr. Horner, to the Centaur.

Mr. Hines, do you have a question?

Mr. HINES. I would assume, and correct me if I am wrong, Mr. Horner, that the gain you got from Vega as applied to Centaur would be reflected in budget appropriations for Centaur—not definable, not discernible, but would be apparent?

Mr. HORNER. This is certainly already true in the year 1960 expenditures on the Centaur.

Mr. HINES. One other question. You use the term "storable fuels" in the same sense the Armed Forces do, that is, long-term standby. If I may answer my own question, that would mean storable just long enough to be utilized for that special flight, and that is all.

Mr. HORNER. Well, just to avoid confusion, we use the term "storable" to mean non-criogenic, and that is the same sense that the Department of Defense uses it.

Mr. HINES. You don't apply a long storage in a warehouse some place?

Mr. HORNER. No, not a long shelf life in that sense.

However, the constraining characteristics of storable fuel are probably ascertainable by the storable life in actual space missions, where it will be necessary to have long storable life on a specific space

mission, while the vehicle is traveling from the earth to some deep space objective.

Mr. HINES. Thank you. That is all.

Mr. SISK. By the way, are there any other questions before we go to Centaur?

If not, I have a short statement here to clarify—I am sorry, I neglected to do this when I convened the committee—to clarify the discussion we had yesterday.

Mr. Horner, I will yield to you at the end of this short statement for any comment you would care to make. This is on that record regarding the priority on the F–1 engine which we discussed yesterday. I will give this statement to you, Mr. Reporter. I am making it in order to clarify the record.

We discussed yesterday, you remember, at some length with what sense of urgency—or lack of urgency—NASA has approached the F–1 project for the development of a 1½-million-pound-thrust, single-chamber rocket engine.

NASA began operations as an independent agency on October 1, 1958. It considered both the F–1 project and Project Mercury of such great importance that on November 14, 1958 it requested of the Department of Defense that a DX priority—the highest national priority—be assigned to both Project Mercury and the F–1 program. However, this priority was not assigned by the Department of Defense and the matter was subsequently taken up with the National Aeronautics and Space Council. On December 3, 1958, the Space Council rejected both requests for a DX priority for Project Mercury and the F–1 program.

On December 9, 1958, the Civilian-Military Liaison Committee recommended to NASA and the Department of Defense that Project Mercury be given top priority. It was the consensus of the Liaison Committee at the time that the F–1 project would be assigned a lower priority.

Present at this meeting, at which it was apparently agreed not to press again for a DX rating for the F–1 project, were the following NASA officials: Abe Silverstein, Homer J. Stewart, Ira H. Abbott, DeMarquis Wyatt, and Abraham Hyatt. The Liaison Committee recommendation was subsequently transmitted to the Space Council.

On April 27, 1959, the Space Council approved a DX rating for Project Mercury. On April 30, 1959, the Department of Defense was notified of the Space Council's action. On May 5, 1959, the Department of Defense assigned a DX priority to Project Mercury.

If any of that is incorrect, although I think it is correct, I would like to have your comment.

If you prefer not to comment until you look these dates over, I will be very happy if you want to make a comment later, Mr. Horner. I wanted to get that into the record in view of the discussion we had yesterday in regard to the procedure with reference to the priority on the F–1 engine.

(The information requested is as follows:)

STATEMENT BY NATIONAL AERONAUTICS AND SPACE ADMINISTRATION ON PRIORITIES FOR THE F–1 ENGINE AND PROJECT MERCURY

On October 14, 1958, a letter was received by NASA from the Office of the Assistant Secretary of Defense, Supply and Logistics, which invited NASA to submit nominations for the Department of Defense master urgency list for calendar year 1959. In response, on November 14, 1958, NASA requested that two projects, the manned satellite and the 1½-million-pound-thrust engine, be placed in the Brick Bat .01 category of the Department of Defense master urgency list. The Brick Bat .01 category in the master urgency list corresponds to the DX category in the industrial priority system established under the Defense Production Act.

Subsequently, on December 3, 1958, NASA reported the request referred to above to the President and the National Aeronautics and Space Council. As an outcome of the discussion which followed the report of NASA's request to the Department of Defense, it was mutually agreed and decided not to pursue the NASA request for the .01 priority on the projects until they could be closely monitored by both NASA and the Department of Defense to determine if any delays were encountered in either program which could be attributed to the lack of a .01 or DX priority. It was further agreed that additions to the DX category should be made only where delays were beginning to develop in order to minimize the dilution of the effectiveness of that list. In the meantime, the Secretary of Defense offered expediting assistance to avoid any particular bottlenecks which might develop.

During the next 3 months, both programs were treated as high priority within NASA and DOD and closely scrutinized to determine whether any delays were attributable to difficulties in the allocation of materials or coordination of industrial facilities. At no time during this period was there any evidence that delays were due to the lack of a DX priority; however, in March, evidence began to accumulate pointing to a need for the higher priority on the manned satellite program if material and equipment supply difficulties were to be avoided. There was not at that time, nor is there now, evidence that the 1500–K engine project has been delayed by the lack of the highest national priority.

Subsequently, with the support of the Department of Defense, NASA initiated a request for a DX priority on Project Mercury to the President. The President approved the DX priority for Project Mercury on April 27, 1959.

Following this, notification of the President's decision was sent to appropriate parties on April 30, 1959. On May 4, 1959, NASA was informed by DOD that the manned satellite program was listed in the DOD master urgency list as having a Brick Bat .01 priority rating.

It should be noted that neither project was ever rejected for a DX priority rating or for inclusion in the .01 priority category of the master urgency list. Rather, as I have noted above, a period of close monitoring of possible delays was agreed desirable to validate the real need for the DX priority rating.

As NASA officials have assured the committee in the past, when evidence appears that significant industrial production problems are identified as resulting from difficulties in acquiring material, equipment, or industrial support, the question of a DX priority for the 1500–K engine project and the justification for the priority, will be taken up with the President.

Now, let us proceed to the discussion on Centaur. This happens to be one of the large items in the portion of the budget which we are considering.

You are requesting $47 million. Right?

Mr. HORNER. Yes, sir.

Mr. SISK. Did you want to make any particular comment on this figure now, Mr. Horner?

Mr. HORNER. I don't have substantial additional information to offer over that that is provided in the budget backup book, Mr. Sisk, except to say that we view Centaur as a very important step in the advancement of our space vehicle capability.

It will be the first vehicle which we will fly in our space exploration program which produces a weight lifting capability that is substantially greater than that which has been shown as yet by the U.S.S.R.

This is of some importance in itself. It is also important in that it provides us the capability to do some space exploration missions, which we will not be able to attempt with a lesser weight lifting capability.

For example, this vehicle produces a weight in space which will permit a useful space craft on a 24-hour orbit. It will also permit a soft landing on the moon.

A lesser payload does not permit a substantially useful spacecraft in either of those two missions.

Mr. SISK. Are there any questions?

Mr. Roush, do you have any questions on the Centaur program?

Mr. ROUSH. I would like to know a little bit more on how these figures are broken down. I see on the next page a breakdown, but, for example, procurement of booster vehicles, $6,500,000, then the large figure 39½ million.

Can you tell me a little more?

Mr. HORNER. Yes, I would like to discuss each one of those a little bit.

The booster vehicle for the Centaur, of course, is the Atlas. The money which you see under the procurement of booster vehicles, $6½ million, is specifically for the incremental funding of the Atlas first stages that will be used in the Centaur research and development program. That is the purchase of the first six Centaur flights.

As I mentioned, this is an incremental funding approach. We do not pay for all of the booster vehicle required in any one year, but we provide money to the contract as required by the contractor.

The next line item——

Mr. ROUSH. Before you go to the next one, may I ask a question on this one?

Mr. HORNER. Surely.

Mr. ROUSH. Is this money paid directly to the contractor or to the Air Force?

Mr. HORNER. We provide the money through the ballistic missile division of the Air Force, who is the contractor—who is the Government agency that is contracting for these particular vehicles in support of the ballistic missile program.

It would be very difficult for us in NASA to contract directly with Convair because we would be impinging on a production line which has to be very carefully scheduled. We find it is most satisfactory to contract through the Air Force so that we have one Government agent doing business with the contractors from every point of view—cost control, materials control, quality control—from every important aspect. It is far better to do this through the other Government contracting agency than it would be for us to contract directly with the industry.

Mr. ROUSH. All right.

Mr. HORNER. If I may go on, then, the next item of $39½ million is for the development and procurement of test quantities of both the second stage vehicle and its engine.

The second stage vehicle is under procurement also from Convair. It has to mate directly, of course, with the top of the Atlas missile. It has to feed guidance signals from this second stage into the control

system of the first stage, and it really is the logical source for the second stage vehicle.

The engine on the other hand is a new engine in terms of rocket propulsion techniques, in that it uses liquid hydrogen as a fuel. It is the first engine—first, the rocket engine development we have had in the United States using liquid hydrogen. It is being developed by the Florida Division of Pratt & Whitney, which in turn is a division of United Aircraft, as you know.

The money you see there provides for the development of the engine, its testing to a flight-rated status, and sufficient experimental engines to provide for the experimental flights, again six of them.

Now, I would note here, as I have before, that each vehicle has two engines. It is a twin-engine vehicle. Here, again, we are contracting through the Air Force as our agent, because the facility is under the jurisdiction, the plant cognizance, of the Air Force. This was a development that was underway in the Air Force when NASA came into being.

The last line of a million dollars is our first stated requirement to support the actual launch operations at Cape Canaveral. This will buy the personnel from the contractors involved, not only the prime contractors of Convair and Pratt & Whitney, but representatives from other contractors for skills such as guidance, or any other ancillary equipment to actually perform the services necessary to the launching.

Mr. ROUSH. How many launches are planned for this particular time period?

Mr. HORNER. In this particular time period I think we are talking about two launches, but I would have to check the books to be sure.

Mr. WYATT. 1961, one launch.

Mr. ROUSH. It will take a million dollars for launching one vehicle?

Mr. HORNER. This, of course, is a continuous process. Once we have the launch crews on station down there, we have to pay this bill.

Now, the first launching is going to be more expensive than follow-on launches, because these crews have to prepare the test stands, the first job of mating the vehicle with the stand is the most difficult job, because all of the ground servicing equipment has to be adjusted to fit the particular vehicle. It always takes longer to launch the first vehicle.

I believe for this first vehicle we have allowed for example a period of 3 months for the vehicle to be at the launch site before it is launched. This is just a process of learning all of the difficulties that we have to overcome before we have a well-functioning launch crew.

Mr. ROUSH. Where is this first launch to go? What is the nature of it? The reason I ask that, I was wondering if it is of the type that should require and perhaps does have a backup vehicle?

Mr. HORNER. Well, it certainly does have a backup vehicle in terms of the fact that we have both or are buying six vehicles to do the early vehicle research and development. We plan on launching these just as rapidly as we can and still assimulate the data that we get from each flight into engineering changes that are necessary on the follow-on vehicles.

So in the sense that we will have two vehicles on the stand, one of which can be used as a backup in case the other one has trouble, we cannot have a backup like that in a vehicle research and development program, because, you see, it would not be useful to fire the second one until we have incorporated what we have learned on the first firing into the second vehicle.

In terms of having a second vehicle available to overcome the difficulties we encounter on the first one, we do have a backup vehicle.

Now, we are always troubled with the question of how much money should we invest in a payload on an experimental vehicle, because we must recognize that the reliability of the first vehicle is not going to be very high, and so we don't want to invest too much money in a payload. On the other hand, if it should fly successfully we would certainly want to get the maximum amount of data return out of it.

We will, as a payload in this first vehicle, have a very substantial amount of instrumentation to tell us what is occurring in the vehicle—that is, research and development instrumentation.

We also provide an embryonic—a rather crude scientific payload, which we can fabricate without too much expense, and which we can reproduce without too much expense if we should have a development problem which results in a disastrous test.

Mr. ROUSH. I have no further questions, Mr. Chairman.

Mr. SISK. Mr. McDonough.

Mr. MCDONOUGH. Mr. Horner, will you inform us what a 24-hour orbit means? Is that a static position to go with the earth?

Mr. HORNER. Yes, sir. That is an orbit at such an altitude from the earth's center that the rate of rotation—that the period of the orbit is exactly 24 hours, which, of course, is the rotational time for the earth, and as a result the satellite appears to stay in the same position, the same place, over a single point on the earth's surface, and, of course, this can be accomplished only at the equator.

Mr. MCDONOUGH. In other words, that satellite flies at a slower rate of speed than the average satellite we have been shooting?

Mr. HYATT. Yes.

Mr. MCDONOUGH. It travels at 1,100 miles an hour?

Mr. HYATT. No, it is faster than that.

Mr. HORNER. It is much faster than that, because the radius is much longer.

Mr. MCDONOUGH. The radius is larger, that is right. But it is certainly not an 18,000-mile-an-hour orbit?

Mr. HYATT. It is nearer 7,000.

Mr. MCDONOUGH. Seven thousand?

Mr. HYATT. Yes.

Mr. MCDONOUGH. This is the first type engine that we have developed for a 24-hour orbit?

Mr. HORNER. This constitutes the first engine which will provide sufficient load-lifting capability that we can place in an orbit this high above the earth a payload that is useful at that distance.

Mr. MCDONOUGH. How are you going to control the speed to keep it traveling at less than 16,000 miles an hour?

Mr. HORNER. Even at that speed it is still faster than the speed that is naturally provided the satellite by the earth's rotation.

To actually produce a satellite at this position it is a very complex guidance and propulsion problem in that in firing the satellite from the east coast of the United States we first have to put the satellite in a stable orbit around the earth at some lower altitude. We then have to, at the equator, change the direction of flight of that satellite, which requires very considerable energy, so that it does stay in the equatorial plane. Then we have to provide additional energy so that apogee of the elipse which results from this acceleration occurs at the altitude of the 24-hour satellite, and when it reaches that apogee we then have to give it another kick so that it will attain the velocity which will just match the rotation of the earth.

Mr. McDonough. Now, once you have accomplished that, what is the life of this satellite in orbit?

Mr. Horner. Almost indefinite. It will diverge from that orbit only by the rather obscure forces of the attraction of the moon, the eccentricities that are provided by other very low level gravitational fields, and such forces as the pressure of solar radiation.

To the best of our theoretical knowledge, these forces are not great enough to disturb the path of the satellite very much in any finite time period, and therefore the life of the satellite is very long.

Mr. McDonough. We can imagine this satellite as being an extension from a certain fixed position on the earth and it travels at that speed all the time, right around with the earth?

Mr. Horner. It stays on an extension of the same earth radii constantly to the extent that it is not disturbed by the other forces I have mentioned.

Mr. McDonough. You speak about the reliability of the first shot, which, of course, is something nobody can anticipate.

Up to now, what have you found are the weakest points in the failures that have occurred in launching satellites into orbit? What are the things that you would look for as being the first thing to go wrong?

Mr. Horner. Mr. McDonough, I would hesitate to point out the weakest points. I would mention several difficulties that have occurred approximately with equal frequency, one of which, of course, is the propulsion system considered as a whole. We have had very few failures after a rocket engine is properly ignited and comes up to full thrust in the engine proper, but there have been several failures in valves, in plumbing, and the connecting equipment of the propulsion system which have resulted in failure to orbit, for example.

There have been a few cases where the propulsion system has failed to produce the total impulse—that is, the total trust times the time that was planned, and because the satellite was planned to take advantage of the total impulse an adequate velocity was then not attained to keep the satellite in orbit, and it fell back into the earth's atmosphere.

I think that probably the next category of happenings which have most frequently resulted in failures has been related to the guidance system. Now, this has run the gamut of failures of actual components in guidance systems which have in turn resulted in the destruction of a missile either because it went out of control, or because it diverted from a safe track and had to be destroyed by the range to such happenings as in some of our satellites we in the final stages depend upon

a form of attitude stabilization which we call spin stabilization. This involves simply spinning up the final stages when they are properly pointed, and then firing the propulsion system and just like a rifle bullet they are stabilized in direction by the spinning action.

In doing this we have had cases where the final stage, after it is properly pointed, runs into some disturbing influence which types it off, either before it is spun or during the spinup, and therefore it is pointed in the wrong direction, and most frequently, of course, either pointed downward toward the earth's atmosphere, or pointed too high, and in either case it will not attain enough velocity to go into orbit.

Now, this, as I would hasten to point out, is a rather embryonic method of guidance. We have used it simply because we have not had the total weight-lifting capacity in many cases which permits us to put a more sophisticated kind of guidance in the final stages. By a more sophisticated kind of guidance, I mean inertial or radial control of the direction point.

In vehicles such as the Centaur, we will have this capacity, we will have in the final stage a direct control guidance system, so we will not have this kind of difficulty.

There have been, I recall one or two failures because of structural failures, but in the whole you can relate most of our failures either to propulsion or to guidance.

Mr. McDonough. When you find there is some effect that has caused it to go out of control, and it is exploded, how do you know what it is that caused the defect since you explode the entire vehicle? Once it is shattered, it is very difficult to recover it and put in together again to find out what went wrong.

Mr. Horner. Almost all of the diagnostic work in such case is dependent upon telemetered records which are radioed back to the launch site, and which are analyzed very carefully. I think we have had in the Nation a remarkably good record of being able to diagnose the difficulties that were encountered, take corrective action, and not have that specific difficulty the second and third time.

Mr. McDonough. What was the defect in the Discovery shot that failed at Vandenberg last week or two?

Mr. Horner. I am not in a very good position to discuss that simply because that is a defense program. I would not like to talk about it in open session.

Mr. McDonough. Now, you said a million dollars is for the crew. Do you have the same crew coming from the contractors out of the launching site? Do you have that same obligation in other launchings for other vehicles?

Mr. Horner. In other vehicle programs we have. We have a line item for the support of launchings.

Mr. McDonough. This is the first one I noticed in this backup workbook. In the other I didn't see any.

Mr. Horner. In the Delta, for example, on page 188, we have in this year's account, range and launching services, and shipping costs, $2,300,000.

I think you will find, Mr. McDonough, there is such coverage in all of the programs where it is required in this particular time period.

Mr. McDonough. That is all I have right now.

Mr. Riehlman. Could I ask one question at that point?

Mr. SISK. Yes, go ahead.

Mr. RIEHLMAN. If you were to continue the same program and you are going to have, we will say, six firings, you can use the same crew and the same equipment that you have so that there isn't any duplication there. Am I correct in that, on this particular firing?

Mr. HORNER. That is correct, Mr. Riehlman.

As a matter of fact, we go to a great deal of care not to even have duplication amongst the individuals at the launch site, and I can afford you an example. We will have at the Atlantic Missile Range, during this time period, launchings of several different kinds of vehicles based on the Atlas as a first stage. The Atlas as a first stage requires the launching services of Convair. We will have interchange of the Convair crew betwen these different kinds of vehicles in order to get the maximum utility out of the crew that is there.

The reason for this is that many of our space launchings are quite far apart in time in order to afford us a proper opportunity to get the maximum benefit out of each launching. One crew can make more than a launch every 3 months, so that we can use that same crew in some cases on different vehicles.

Mr. RIEHLMAN. On different projects, yes.

Mr. SISK. If the gentleman from New York desires other questions, go ahead.

Mr. RIEHLMAN. I lost my thought here.

Go ahead with Mr. Morris.

Mr. SISK. The gentleman from New Mexico.

Mr. MORRIS. I have no questions, Mr. Chairman.

Mr. SISK. While Mr. Riehlman is checking up on his questions, Mr. Hines has a question.

Mr. HINES. This is a question of academic interest.

You say the satellite will stay in one point in an equatorial plane. Would it shoot the position to the mobiling of the earth's axis?

Mr. HORNER. There undoubtedly will be some random movement of such a satellite, and to take care of that we do provide in the spacecraft itself a low-level propulsion system for what we call "orbit adjustment." I am sure this is going to be essential to keep it in proper position.

I would like to point out that it will stay in one point only over the equator. If it is north or south of the equator, as the earth rotates, because of the angularity of the earth's axis, it will process north and south.

Mr. HINES. It has that capability?

Mr. HORNER. It is absolutely essential.

Mr. RIEHLMAN. Mr. Chairman, I have one or two questions.

At the close of the statement here you say that the final design of the Centaur powerplant in the second stage will be completed and flight-test programs will be started during the fiscal year 1961.

You have scheduled six firings, am I correct, and one of them will start in 1961?

Mr. HORNER. Actually, there is only one. It is currently scheduled, I believe, in June, which is the last month of fiscal year 1961, but, of course, we do have to make some investments in order to keep that schedule.

Mr. RIEHLMAN. Well, now, in your previous statement you said that the Centaur would have the thrust to make a soft landing on the moon. Am I correct in that?

Mr. HORNER. That is correct; yes, sir.

Mr. RIEHLMAN. Will this be used for that purpose?

Mr. HORNER. It is our intention to provide with the Centaur vehicle a spacecraft which will soft-land instruments on the moon.

Mr. RIEHLMAN. Yes, that is what I wanted to know.

Do you have a time date on that that can be given, or a schedule at all?

Mr. HORNER. It is in the 1962 time period.

Mr. WYATT. Fiscal year 1963 time period.

Mr. HORNER. I think it is the last half of calendar year 1962.

Mr. WYATT. It would be the first half calendar year 1963.

Mr. SISK. Pardon me, which would actually be in the calendar year 1962?

Mr. WYATT. The first half of calendar year 1963, which is the last half of fiscal year 1963.

Mr. HORNER. I was wrong in saying 1962.

Mr. SISK. Oh, in the calendar year 1963. It is that far away?

Mr. WYATT. Yes, sir.

Mr. RIEHLMAN. Those are all the questions I have, Mr. Chairman.

Mr. SISK. Mr. Wilcove.

Mr. WILCOVE. Mr. Horner, could you give me an estimate of the total cost of the program?

Mr. HORNER. I wonder if you could define it. Do you mean the total cost of the development program?

Mr. WILCOVE. Yes. Will you need additional funds in 1962, for example?

Mr. HORNER. Yes, we would.

Mr. SISK. If I might comment——

Mr. HORNER. It is going to be on the order, I believe, of $120 million to finish up the development of the Centaur.

Mr. WILCOVE. Is that the total?

Mr. HORNER. Through what we are presently calling the development program.

Mr. SISK. If I could clarify. What I think Mr. Wilcove has in mind, maybe, is the cost of it. We were talking about the cost on Scout the other day. We are talking about what it costs to buy a Delta. What is it going to cost to buy a Centaur?

Mr. HORNER. A single Centaur vehicle?

Mr. SISK. No, I was not thinking about that. You are certainly going to have a number of vehicles, because you are going to have to have backup vehicles. In other words, does NASA have any figures on the overall buying cost of Centaur as a vehicle to complete and actually put it to the position of what you might call operational, using the military language?

Mr. HORNER. All right, sir, may I define my terms? We don't really have enough experience yet to say with confidence when a vehicle is operational, when it has completed the development program, because, you see, in the final analysis this depends on reliability, and how well we do in producing a reliable vehicle.

We have estimated that it will take at least six development vehicles before we can consider the vehicle as operationally ready to take a full investment of a payload. On the other hand, as I said previously, we will have some you might say operational utilization of these first six vehicles, too.

We estimate that it will take for the vehicles through these first six shots, $120 million. In this time period, of course, we will have some additional investment in the payloads that we put on these first six vehicles and, of course, we will have to make long leadtime investments for vehicles beyond the first six.

Whether or not you say the seventh vehicle is operational or not depends almost entirely on the definition you give the operational vehicle in the terms of the reliability you might expect.

Our history has been the more vehicles you fire the more reliable they become.

Mr. SISK. If I might interrupt you there, Mr. Horner. For example, the other day in Dr. von Braun's discussion before the committee—I think you were there, were you not?

Mr. HORNER. Yes, sir.

Mr. SISK. He discussed at some length the Saturn, and I am anxious to get to your presentation here, because I see you have some material here on Saturn. He talked about, I think, and used as a figure, the 11th vehicle, if I am not mistaken. He said, all right, and, of course, certainly your whole program in a sense is research and development, because this is a scientific experiment proposition from start to finish, anyway.

Apparently he used in that instance a cutoff by saying with the 11th vehicle we will do the ultimate we expect to do with this particular piece of equipment. That was my understanding.

Now, I was trying to apply——

Mr. MCDONOUGH. That was Saturn he was talking about.

Mr. SISK. I mean Saturn.

Mr. HORNER. Saturn was my understanding.

Mr. SISK. Yes, when Dr. von Braun was testifying. I was trying to use that same yardstick to apply to Centaur. Maybe you can't use that yardstick, I don't know, but that was the yardstick I had in mind.

Mr. HORNER. In a sense you can use that yardstick. We have been speaking of the 7th vehicle in the terms that Dr. von Braun was speaking of the 11th vehicle. All of these programs are different.

For example, in the seventh vehicle we do not expect to attain the 24-hour orbit yet, and there will be further development required in order to attain with confidence the 24-hour orbit, because it is a very complex mission. It is one of the most complex missions we have to undertake.

Mr. MCDONOUGH. Will the gentleman yield there?

Mr. SISK. Yes, go ahead.

Mr. MCDONOUGH. Well, now, we speak about each one of these projects as being individual in its many aspects of reliability, and the engine payload and the various stages. What I am trying to resolve in my own mind is this: Don't we learn by experience from all of the other projects certain things to correct in any one that we are operating on? In other words, Centaur is not so completely new

that nothing like this has ever been done before, except that it is a 24-hour orbit vehicle.

Now, what is the difference? You say, well, the liquid hydrogen is another new feature of it, but it is a satellite put into orbit by a rocket engine. Rocket engines—we know what rocket engines are, we have had enough experience with them.

Don't we learn from the other projects some of the errors that may creep into the one we are working on?

Mr. HORNER. We certainly do.

There is a great deal of coupling between all of these projects. There is, for example, in the Saturn and the Centaur a direct relationship in the actual hardware, because the upper stage of the Centaur—that is the liquid hydrogen stage, that goes on top of the Atlas, is also being used as the third stage of the first version of the Saturn.

Now, because it is going on the Saturn, and because it will take greatly increased payloads, there have to be some modifications to it. But it is important to note that it will be done by the same contractor, by the same people. It uses substantially the same engine, although it, too, will be uprated, and there will be a great deal of crossfeed between the Centaur and the Saturn.

Mr. MCDONOUGH. However, up to now we have not shot either one of them?

Mr. HORNER. The only thing that has actually been shot in connection with either of these two vehicles is effectively the first stage of the Centaur, which is the Atlas intercontinental ballistics missile.

Mr. MCDONOUGH. Do we consider that to the point of reliability at the present time?

Mr. HORNER. Of course, we could be nothing but satisfied with the most recent performance of the Atlas. I think there have been a total of 19 shots of the Atlas that have been completely successful without a single failure. We would be hard put to describe a more reliable device.

I feel certain that there will be additional failures at some point along the line.

Mr. RIEHLMAN. We have not anything more reliable, have we?

Mr. HORNER. No, sir. I do not see how anything can be more reliable than that at the present time.

Mr. MCDONOUGH. What else do we have in the status of reliability in addition to the Atlas?

Mr. HORNER. Well, of course, in that size, that is the only device we have at this time. The next size down is the IRBM size, which is a single rocket engine first stage, in which we have both the Thor and the Jupiter.

They, too, have both been very realiable.

Mr. MCDONOUGH. Then our problems are largely on the second and third stages?

Mr. HORNER. On upper stages, that is very true.

Mr. MCDONOUGH. Where our experimental work is being done at the present time?

Mr. HORNER. Well, that is true with the exception of Saturn, of course, in which we are doing a great deal of work on the first stage, and of course we have engine development such as the F–1, which are designed for first-stage utilization.

Mr. SISK. Mr. Wilcove.

Mr. WILCOVE. Then the research and development program, including the cost of the six vehicles, is a total of $120 million. Is that correct?

Mr. HORNER. Yes, and I would just like to emphasize that is a rather arbitrary boundary. We will have research and development going on after that.

Mr. WILCOVE. The seventh vehicle, assuming it is operational—let us call it operational—will be when? What time would you estimate?

Mr. HORNER. The second half of calendar year 1962, the first half of fiscal year 1963.

Mr. WILCOVE. How many companies are involved in the contract—in the program, rather?

Mr. HORNER. Centaur?

Mr. WILCOVE. Yes.

Mr. HORNER. I could not test my memory to call out all of them.

Mr. WILCOVE. Who are the major contractors?

Mr. HORNER. The major contractors are Convair on the stage structure, Pratt & Whitney on the engine, Minneapolis-Honeywell on the guidance—we have the jet propulsion laboratory working on space craft.

I think that covers the major contractors. There are, of course, numerous subcontractors.

Mr. WILCOVE. Pratt & Whitney is working on the engine?

Mr. HORNER. Yes.

Mr. WILCOVE. Would a substantial part of the $120 million go to Pratt & Whitney?

Mr. HORNER. It is a very substantial fraction.

Mr. WILCOVE. Do you have an estimate of how much it would be?

Mr. HORNER. It is on the order of one-fourth to one-third.

Mr. WILCOVE. You can correct your figures later for the record if you care.

Mr. SISK. Oh, yes, sir. I realize some of these are speculative, because these are questions that you probably were not expecting. If you can correct them more nearly to exact amounts, you will be given that opportunity, I am sure, for the record.

Mr. HORNER. I do have one other difficulty, Mr. Chairman.

When it comes to stipulating precise amounts that we have planned to go to specific components of American industry, I would rather not have that in the open record, because it does become a problem to us in our negotiating posture of follow-on contracts.

Mr. SISK. I can understand your problem there. I think it might be just as well if you could speak in percentages, of course, as nearly as possible, and give us as accurate percentages on an estimated basis. That would probably be all right. I think that would keep you off the hook, would it not?

Mr. HORNER. Yes, sir; if we can speak in broad terms.

Mr. SISK. Well, that is what I mean. In other words, we are taking a figure here of $120 million. As I understand Mr. Wilcove's statement, it is about what percentage of that is engines, and what percentage is going to be other types of hardware and problems, such as guidance, and so on.

It seems to me that you should not have too much of a problem of at least pinning down fairly reasonably the percentage figures on these.

Mr. HORNER. All right, sir.

Mr. SISK. Is that all?

Mr. WILCOVE. That is all.

Mr. SISK. All right.

Are there any other questions now on Centaur?

I think we have gotten pretty——

Mr. WILCOVE. Excuse me, Mr. Chairman, one other question.

You have through 1961 a total of $88 million, including the full amount for 1961, if authorized and appropriated.

That would leave about $32 million to finance the program. Do you plan to ask for that amount for 1962?

Mr. HORNER. We will undoubtedly have to ask for more than that, Mr. Wilcove, because we will also need in fiscal year 1962 money for follow-on firings and even further development, in the fiscal year 1963 time period, which will have to be covered—you see these will be requirements beyond the first six shots.

Mr. WILCOVE. Thank you.

Mr. SISK. All right. If there are no further questions on Centaur, let us move on now to Saturn.

Actually, now, what we have here are two more programs. We have the Saturn program, which amounts to $134 million, and we have then the last program that we have to consider here, which is the tracking and data acquisition program for over $32 million.

I had hoped we would get through the discussions of these two items today, but we may not. If not, we will have to continue tomorrow.

Of course, I do not mean that we can conclude then. We still have to pass on these figures. It may not be we can move that rapidly. I do not know. We actually are going to have a hearing on Friday, Mr. Horner, because of our nuclear propulsion situation. We are going to hear the AEC witnesses Friday morning. I would imagine we would like to have you people available for Friday afternoon to review some of their testimony, because, based on my understanding of it, we would like to discuss what NASA is doing in this nuclear field due to some questions that have arisen.

Let us go to Saturn now. I notice you have some material there. Did you want to go into a little further discussion on Saturn at this time?

Mr. HORNER. We thought it might be useful, Mr. Chairman, to refresh your memory on some of the facts concerning the Saturn development program.

I think most of the information that is shown on these charts has been given the committee in one form or another before, but it might be useful just to review it for a moment now as a prerequisite to your questions.

Mr. Hyatt will undertake to do that.

Mr. SISK. Very well, Mr. Horner. Now, this is actually broken down into five specific amounts here, between development and fabrication of first stage, and then the upper stages, the guidance and control, instrumentation, ground service equipment, and then direct material.

Now, it is my understanding—and this is one thing I would like very much to have you comment on this afternoon—it is my understanding that shortly there is going to be a pretty substantial contract coming up on this. Isn't that true?

Mr. HYATT. Yes.

Mr. SISK. You are even now in preparation or asking for the outlining of plans by the various companies, or offered proposals.

Mr. HORNER. We have asked proposals for a second stage for the Saturn vehicle to be delivered to us on the 29th of February.

Mr. SISK. That was my understanding.

I do not wish for you to get into something here that might cause you a problem. I don't know how many companies are going to be offering proposals. I don't wish to tie your hands by something that you might say, but I would like as much information as we could get with reference to the size of this contract and some of the things possibly that may be involved in it. Because here again, I would hope you would have some comment looking ahead again to the ultimate cost overall of this package, whether it be the 7th vehicle or the 11th vehicle or the 27th or what it be. And I realize this is speculative to a large extent. But how much money overall are we talking about in the Saturn proposal or program?

Are we talking about a billion dollars? I can visualize where we might be, but I do not know.

Mr. HORNER. Yes, sir, we would be glad to address ourselves to those points.

I wonder if it would be desirable first just to review the configuration and the schedule which is shown on these charts, then I will address myself specifically to the line items in the budget.

Mr. RIEHLMAN. While you are making your presentation, the Dr. Von Braun group is in this program.

Mr. HORNER. They are.

Mr. RIEHLMAN. It would be helpful to know what portion of it they are going to carry out.

Mr. HORNER. I would be glad to. That is directly related to this question.

Mr. RIEHLMAN. Yes.

Mr. HORNER. Because we had at least one unique line item in this development, inasmuch as we do have a major fabricating effort going on within the Government facility.

Then, if Mr. Hyatt might just review these charts.

Mr. HYATT. This first chart on the right (fig. 10), we will go through it quickly. It shows the Saturn configuration.

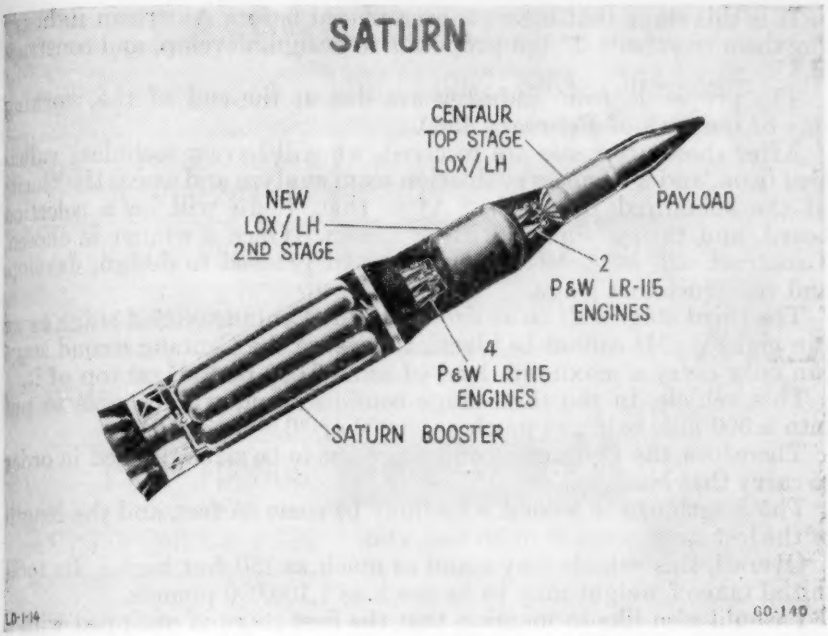

FIGURE 10

The first stage has a cluster of eight engines. The engines are the same as a single engine of the Atlas type or the Thor IRBM.

In this particular case they will be operating at a thrust of 165,000 pounds.

The inner four engines are fixed, they do not move. The outer four engines are gimbaled and can move in any direction to provide the necessary control.

The tankage is composed of eight outer tanks, which are modifications of the Redstone missile tanks. The one inner tank is a modification of the Jupiter missile tank.

Four outer tanks contain the kerosene and the inner tank plus the four remaining outer tanks contain the liquid oxygen.

The total width of the first stage at the tanks is 22 feet. Its total height is about 80 feet.

The second stage is the stage that Mr. Sisk asked about.

Mr. MCDONOUGH. The total height of the first stage is about 80 feet.

Mr. HYATT. That is right. Then, of course, there is the intermediate section that connects first stage to the second stage. That is that portion which is in black there on the chart.

Now, the second stage is a liquid-oxygen, liquid-hydrogen fuel stage, and similarly the third stage has the same propellent.

The second stage has four engines. These are engines that are developments of the Centaur engine. They will be as nearly the same as we can make them, but they must be upgraded to have 20,000 pounds of thrust each, rather than 15,000 pounds that the Centaur has.

It is this stage that has now been placed before American industry for them to submit design proposals to design, develop, and construct it.

The proposals from industry are due at the end of the working day of the 29th of February 1960.

After these proposals are received, we will have a technical valuation team, and a business evaluation team analyze and assess the merits of the submitted proposals. After that, there will be a selection board, and then a winner will be chosen. Once a winner is chosen, a contract will be negotiated and he will proceed to design, develop, and construct that stage.

The third stage will be as similar to the Centaur second stage as we can make it. It cannot be identical because the Centaur second stage can only carry a maximum load of some 9,000 pounds on top of it.

This vehicle, in the three-stage configuration, will be able to put into a 300-mile orbit, as much as 28,000 or 30,000 pounds.

Therefore, the Centaur second stage has to be strengthened in order to carry that load.

The length of the second stage may be some 35 feet, and the length of the last stage some 30 or 35 feet, also.

Overall, this vehicle may stand as much as 150 feet high. Its total initial takeoff weight may be as much as 1,100,000 pounds.

I would also like to mention that the first stage is equipped with a recovery system. We would like to recover this stage for two reasons. We do not know at this time which one of these reasons will predominate. One of the reasons is that if something goes wrong, we would like to be able to recover the stage, inspect it, and thereby correct the deficiency more quickly than we can if we just telemeter the information.

The second reason is strictly economical. It might be that because the costs of this stage are so great that we can recover it, refurbish it, and reuse it again.

We do not know at this time that this will be feasible. However, it it worth making a try.

Thus, the first stage is equipped with mechanisms and apparatus which, once it has completed its firing, it is separated from the rest of the vehicle, it drops back into the atmosphere and at a predetermined altitude parachutes open up and lower it slowly to the surface of the water. At that point some retrorockets are fired slowing it down almost to a stop, then it enters the water. We hope to have some special Navy craft that will come up alongside it and lift it aboard.

Mr. McDonough. What elevation will it be when it has completed its firing?

Mr. Hyatt. Approximately 30 miles.

This is a quick review of the actual configuration.

The next chart (fig. 11) I have explains the schedule. This is the same chart that Dr. von Braun showed to this group. The first black line indicates the schedule that was proposed when the 1961 appropriations for—rather, 1961 request for funds for this program was $140 million.

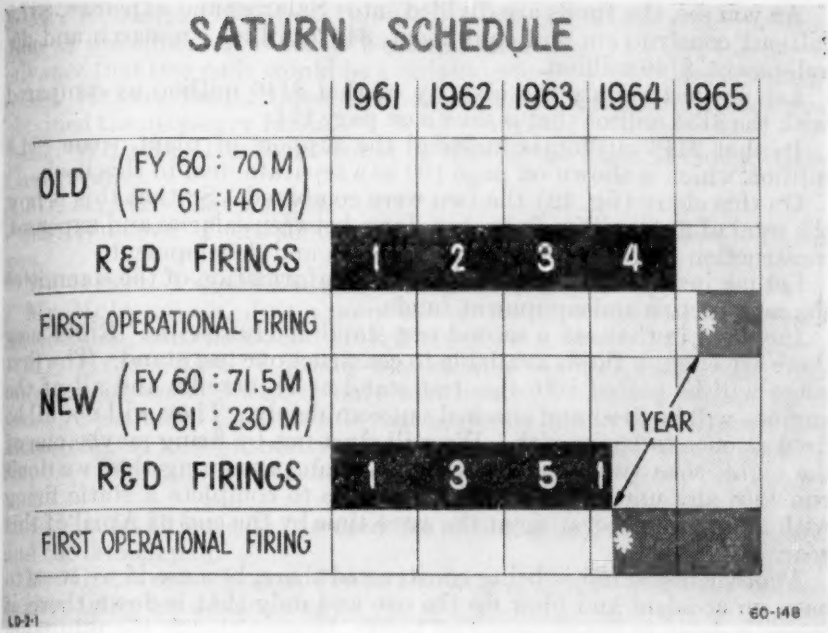

FIGURE 11

As you see, that indicated one firing in calendar year 1961, two in 1962, three in 1963, and four in 1964. Our 11th firing, which we have arbitrarily designated as operational, would have taken place in the first half of 1965.

The President's request to increase the funds for this program from $140 million to $230 million enables us time to reduce by a full year the firing of the 11th vehicle. So that now the schedule calls for still a fire firing in 1961, three firings in 1962, five in 1963, and one in the first quarter of 1964.

In the development schedule shown here, for the first three missiles, only the first stage will be live, the upper two stages will be dummies.

The next three firings, the first two stages will be live, and the third stage will be dummy.

And the last four firings, we hope, will be complete three-stage vehicles.

Now, if I may have the next chart (fig. 12) before Mr. Horner answers the detailed questions, I will show the overall funding chart again that Dr. von Braun showed this group earlier.

FIGURE 12—*Saturn funding*

[In millions]

	1960	1961
Salaries and expenses	$27.9	$37.5
Construction and equipment	6.2	46.5
Research and development	37.4	146.0
	71.5	230.0

As you see, the funds are divided into: Salaries and expenses, $37.5 billion; construction and equipment, $46.5 million; research and development, $146 million.

Let me just supply the identity of that $146 million as compared with the $134 million that is shown on page 194.

In that $146 million is included the support of plant, some $11.8 million which is shown on page 109 as a separate item in this book.

On this chart (fig. 12) the two were combined. So that this is how the total of $230 million is broken down between salaries and expenses, construction and equipment, and research and development.

Let me just cover very quickly for the information of the committee the construction and equipment funds.

Included in that are a second test stand at Huntsville. Right now there are enough funds available to construct one test stand. The first stage will be placed into this test stand at Huntsville and all of the engines will be fired and checked out completely. They will not all be fired at once to begin with. We will start out by firing maybe one of the eight, then two, then four, then six, and assuming that we don't run into any unusual difficulties we hope to complete a static firing with all engines operating at the same time by the end of April of this year.

Another test stand is being constructed there, because if we were to have an accident and blow up the one and only that is down there, it means a delay in the program of 1 year, because that is the minimum leadtime in order to construct another stand.

Mr. WILCOVE. Is that stand under construction now?

Mr. HYATT. The first stand is almost completed, in fact it is completed, but we are requesting additional funds to construct another one.

Mr. WILCOVE. When do you plan to begin the construction if you get the money?

Mr. HYATT. As soon as the money is available.

Mr. SISK. They are included in the fund?

Mr. HYATT. They are included in the fund.

Mr. WILCOVE. That would be in July, then?

Mr. HYATT. If the funds are available July 1 we will start.

And then an additional big item in the construction funds is another launch complex at the Atlantic missile range.

Right now, one is under construction, again, because of the importance of this program. We feel it is necessary to have two down there in case of an accident to one. Again we could be delayed from a year to 18 months or longer just waiting for a test stand to be built.

So we are requesting funds to construct another one.

Mr. WILCOVE. If you were to have an accident on your first test, your program would then be considerably delayed, would it not?

Mr. HYATT. Yes, it would.

Mr. WILCOVE. For how long?

Mr. HYATT. It would certainly be delayed until we have the second test——

Mr. WILCOVE. About 18 months.

Mr. HYATT. A minimum.

Mr. SISK. Let us not have any accident on the first one.

Mr. HYATT. We will be careful.

Mr. WILCOVE. Of course, this matter was not under your jurisdiction at the time, but it seems it should have been planned further in advance that two pads would be available when the first tests are made.

Mr. HYATT. Yes; I think that would have been wise, if they had obtained the necessary funds.

Mr. WILCOVE. The same would be true of the flight stands at Cape Canaveral.

Mr. HYATT. That is right.

Mr. WILCOVE. There should be two ready for the first test. Thank you.

Mr. HYATT. I would like also to mention——

Mr. MCDONOUGH. Just a point there. In the event you do not have an accident, can the second launch stand be used for other purposes?

Mr. HYATT. Yes. I would like to amplify this point, sir. The question of an accident is only one reason. Another reason is, in order to maintain the schedule that is shown on the lower line of that chart (fig. 12), we actually need two test stands and two launching stands. We cannot launch five vehicles in 1 year from one launch pad.

So that in either case, we need the second stand, both the test stand and the launch pad.

Mr. RIEHLMAN. Is that due to the length of time you have to have in preparing for a launching?

Mr. HYATT. This is right. This will be the most complex vehicle by far that this country has ever launched. The amount of checkout time, and the number of checkout procedures that would be required will just swamp anything we have done to date.

I would like to mention one more point, and this is that since the first of the year the President has requested and has assigned a DX priority, which is the highest national priority that we have, to this project.

I think that that gives a quick review of the status of the Saturn project.

Mr. SISK. The gentleman from New Mexico.

Mr. MORRIS. While we are on these test stands, are there any other facilities besides the ones you are speaking of, test stands already built to do this work?

Mr. HYATT. No, sir; we cannot, because of the size of this vehicle. As you see, the largest missile we have today, which is an ICBM, has a diameter of only 10 feet. And its thrust is only some 350,000 pounds. Here we will have a million and a half pounds of thrust. We will have a weight here that is three times the total weight of one of the ICBM's, and the present launch pad complex simply cannot do the job.

Mr. MORRIS. What is this additional stand going to cost?

Mr. HYATT. We are requesting in this budget $21 million for that stand—the entire complex.

I would like to say this is not just a stand. It includes a blockhouse, and it also includes the preparation of a site for the complex. It will be built just north of the present one, which is complex 34, at Cape Canaveral. The ground has no improvements on it now. Roads have to be built, utilities brought in and all other kinds of site preparations made. All items are included in the cost.

Mr. SISK. This static firing in April which you are talking about, that is going to take place at Huntsville, isn't it?

Mr. HYATT. Yes, at Huntsville.

Mr. SISK. That is a static firing prepared in Huntsville?

Mr. HYATT. That is right.

Mr. SISK. Are you preparing a second static stand at Huntsville also?

Mr. HYATT. We are requesting funds in here to build a second test stand in Huntsville; yes, sir.

Mr. SISK. Go ahead.

Mr. MORRIS. Mr. Chairman, may I ask one more question?

Mr. SISK. Surely. Go ahead.

Mr. MORRIS. There are not any other static test stands in the country already built that you can use?

Mr. HYATT. There are not.

Mr. HORNER. The static test stand on which the first static test is going to be conducted is a modification of a stand that was built for the Jupiter program. So in that sense that is being used for the static test. It is utilizing the only available static test stand at Huntsville.

Mr. HYATT. Mr. Morris, I think you should also understand the sheer size of this first stage, 80 feet long and 22 feet in diameter, makes movement around the country a very, very difficult thing. It will, for example, as presently planned, be put on barges and be moved down to Cape Canaveral via barges, and hence to just move it after it is constructed at Huntsville, to any other arbitrary point around the country would be a very, very difficult thing. So we build it at Huntsville, test it at Huntsville, and then move it to the Cape Canaveral to fire.

Mr. SISK. Are there any other questions?

To get this clear, you actually are going to have two static stands at Huntsville. Then you are proposing to build two stands at Cape Canaveral for firing purposes?

Mr. HYATT. That is right.

Mr. HORNER. There is money in this budget authorization request for both an additional static test stand at Huntsville and an additional launch stand at Cape Canaveral.

Mr. SISK. Good.

Mr. HORNER. It is not in this research and development account. It is in the construction account.

Mr. SISK. I realize it is in the construction money. The figures we are looking at are strictly research and development as against the construction and salaries, which are in other parts of this same backup book.

I notice a statement here under the justification, where it says the final version of Saturn will use uprated engines giving a thrust of at least 2 million pounds.

I had not heard any particular comment on that. Did that come out in Dr. von Braun's statement the other day?

Mr. HORNER. Yes, I think Dr. von Braun mentioned that.

The version of Saturn which Mr. Hyatt has been talking about here, by the nomenclature invented at the laboratory developing the vehicle is known as the C–1 version. It is a three-stage device. It will produce a very marked increase in our payload lifting capability.

There is still further development inherent in this particular design.

The proposal, which is still further down the line than the development we are considering here is to uprate the eight first-stage engines to 250,000 pounds each, which will then produce a total first-stage thrust of 2 million pounds.

This will, in turn, permit a greater load of propellant in upper stages, and larger upper stages, and this will in turn permit a much larger payload capability.

This is not the development we are working on today, however.

Mr. SISK. The gentleman from California.

Mr. MCDONOUGH. Saturn, you say, has six engines?

Mr. HYATT. It has eight engines in the first stage.

Mr. MCDONOUGH. Eight engines in the first stage, each with a thrust capability of what?

Mr. HYATT. 165,000 pounds initially.

Mr. MCDONOUGH. Is it planned that Saturn will eventually use the F–1 engine?

Mr. HORNER. No, sir; it is not at the present time.

We have looked at this as a possibility. However, Saturn is designed on the basis of using tooling that is available at the Huntsville facility which was originally purchased for Redstone and Jupiter. The body of the first-stage is nine separate tanks, five of which are used for liquid oxygen, four of which are used for the fuel.

This combination of tanks would make the use of a single engine quite difficult and quite an extensive further development beyond the Saturn.

Mr. MCDONOUGH. In other words, the engine production, then, for Saturn, is all in-house operation, at Redstone?

Mr. HORNER. The engine production is actually with North American Rocketdyne. These engines were developed as a part of the ballistic missile program. They are further improved for this program, and they are being purchased in Rocketdyne.

Mr. MCDONOUGH. You say the tanks are being constructed at Redstone?

Mr. HORNER. The tanks are being constructed at Redstone—the tanks and the whole missile body and the assembly is done at Redstone.

Mr. MCDONOUGH. I see. The outside compartments?

Mr. WYATT. All the parts of the engines, including the parts purchased.

Mr. HORNER. There are many, many individual components that are purchased from industry, and this in effect is what is represented in this firstline item here of $57½ million.

Mr. MCDONOUGH. Yes.

Mr. HORNER. The development and fabrication of the first-stage boosters.

Mr. MCDONOUGH. The development and fabrication of the upper-stage boosters, this figure of $42,300,000——

Mr. HORNER. That money is for purchase of the second stage and the third stage from industry. The third stage will be purchased from Convair and from Pratt & Whitney.

As I mentioned earlier, it is substantially the Centaur stage.

The second stage will be purchased from the contractor which wins the current source selection process and becomes the successful contractor on the development and fabrication of that second stage.

Mr. McDonough. Is that because the second stage is entirely new design and new type construction?

Mr. Horner. It is.

Mr. McDonough. There has never been any precedent for it?

Mr. Horner. That is a liquid hydrogen and liquid oxygen tank. The third stage is also liquid hydrogen and liquid oxygen, of course, but this is a much larger tank. It has a total diameter of 220 inches, and it has four liquid hydrogen engines.

So it is a brandnew development in terms of structural design, and design of the integration of the components.

Mr. McDonough. For your guidance control and instrumentation you have $12,800,000.

Is that any special design? Is there any research and development there, or is that on existing hardware that we know about?

Mr. Horner. That is substantially for the procurement of hardware that has already been developed.

Of course, in adapting any guidance system to a new vehicle, there is a certain amount of development that is necessary because the guidance system must be tuned to the structure of the particular vehicle. The natural frequencies of the vehicle, the response rate that is a function of the mass, and the structural characteristics, determine the response rates that are required in the guidance system, and therefore one can get real value from taking a guidance system that has been developed for another vehicle, but there must still be some additional development in order to adapt it to this particular vehicle.

There is a relatively small amount of this $12,800,000 which is actually development work, of about half a million dollars, and the balance then is for the actual procurement of the guidance systems for the early vehicles that will be flown.

Mr. McDonough. How reliable are the guidance systems that we have been using?

Mr. Horner. Well, as I mentioned earlier, the guidance systems, as a whole, the guidance and control, have been one of the areas in which we have had failures.

However, they are becoming more reliable as we use more of them. We have a very major effort in engineering them to provide a simple mode of operation, more independence from vehicle malfunctions, and we expect little difficulty in providing a reliable guidance system for the Saturn at this particular time period.

Mr. McDonough. What is the basis of the most reliable guidance system we have on high-speed rocket engines?

Mr. Horner. We would have to say at this time, simply because of the Atlas experience, that the radio guidance system which in a sense is a combination of radial inertial, has been the most reliable, simply because we have had this excellent experience with the Atlas and the Atlas causes that experience.

Mr. McDonough. That is ground control?

Mr. Horner. That is ground control, in the sense that it is ground control of inertial elements already in the vehicle which are largely auto-pilots.

Now, both the Thor and the Jupiter have had completely integral inertial systems that are alined and programed before takeoff and have no reference to ground monitoring thereafter. They have been very reliable too, and their reliability has been improving.

Based on the Atlas experience, their reliability hasn't quite come up to that standard yet, but inherently they are just as reliable, and of course they are much more useful in the missions that we need to use them for in space exploration.

Mr. McDonough. What is the principle of that inertial guidance?

Mr. Horner. The principle is a gyro stabilized reference table to which the missile attitudes are compared. Whenever the missile deviates from a programed attitude relative to this stable table, the signal is sent then to the propulsion device which is swiveled to give attitude correction to the vehicle.

A similar signal is provided for cut off of the stages when the desired velocity is attained.

Mr. McDonough. Is that similar to the principle we used in guiding the submarine under the North Pole?

Mr. Horner. Yes, sir; very similar. In fact, some of the hardware is identical.

Mr. McDonough. That is being improved to make it more reliable?

Mr. Horner. Yes, sir; more reliable and lighter weight.

Mr. McDonough. I think the first the committee had knowledge of it was the model that was brought in by someone from MIT.

Mr. Horner. Dr. Draper, I believe, from MIT.

Mr. McDonough. Dr. Draper; oh, yes.

This direct material, what does that include?

Mr. Horner. This is the line item which I mentioned earlier as being unique to this particular vehicle development, because it is—this is the only vehicle in which we are doing substantial in-house fabrication.

This is actually for the procurement of the basic materials, the sheet metal, the metal stock, which goes into first-stage fabrication at the Huntsville facility.

Mr. McDonough. Would it take $12 million for that?

Mr. Horner. Some of this material is quite expensive, in terms of stock cost.

Mr. McDonough. And the $12 million will provide you with how many of these?

Mr. Horner. We do, of course, have a leadtime problem on this kind of material. We must have it in hand when it is required, and therefore we must buy it in economical lots and have a storage capability.

This will actually buy material for the following year's operation.

Mr. McDonough. This isn't such a complex operation; it is a boilermaking operation, isn't it, or is it more than that?

Mr. Horner. There is a certain fraction of the work which you might describe that way, Mr. McDonough. However, there is a large fraction of the work which is very large construction, and yet must be to very close tolerances.

Mr. McDonough. I see.

Mr. Horner. So it does require careful material selection on the part of the design engineer, and it does not pay to economize in the selection of material for one of these vehicles.

Mr. McDonough. Does this include also the recovery apparatus that you hope to install in order to recover?

Mr. Horner. The recovery apparatus is actually a subcontract, and I don't believe there is any material procurement for that except some of the compartmentalization for the recovery apparatus, that is, the actual structure of the compartment for the recovery.

Mr. McDonough. That is all, Mr. Chairman.

Mr. Wyatt. Mr. McDonough, I will say this is more analogous to the construction of a modern high-speed airplane fuselage than it is to a boiler manufacture.

Mr. Sisk. The gentleman from Indiana.

Mr. Roush. I consider the Saturn program as the most important program we are undertaking today, because I feel this is the one way we can assure the American people we are capable of catching Russia in the space race.

Is the Saturn project now programed so as to go forth at maximum speed?

Mr. Horner. I think Dr. von Braun, in response to similar questions, described the rate which this authorization request would permit as an optimum rate.

He stated that additional money might provide a small, relatively small improvement in time schedules, but there certainly would be a decrease in the return per dollar invested.

I have discussed this at great length with Dr. von Braun. All I can say is that I would endorse his description of that situation as regards the resources that are provided to him.

Mr. Roush. Is there any area included here in this portion which you are presenting today, or which we are considering today, in which the funding is in your opinion inadequate?

Mr. Horner. Well, I am of the opinion that the funding is adequate to carry out the time schedules we have described with this program.

Mr. Roush. Do you concur in the time schedules?

Mr. Horner. Yes. I think the time schedules are very progressive, and we are going to have to extend ourselves to provide spacecraft that will meet these time schedules and make full utilization of the weight-lifting capability that these schedules provide.

Mr. Roush. Then you are saying that this funding is in every respect adequate. Is that correct, Mr. Horner?

Mr. Horner. Mr. Roush, I would only qualify my comment to that question to point out again that this is a research and development program.

Our schedules of necessity change from year to year, sometimes almost from month to month, depending upon the research and development difficulties we find.

It is entirely possible that next year we will have to come back and ask for more money to do some of the tasks that we have said that we are going to do with the money we are asking for this year.

This is a part of the research and development business.

But to our best judgment at this time, the money is adequate to meet these schedules.

Mr. Roush. It is not my intention to put you on the spot for next year, but I am asking your personal opinion as to this year. If there is any area in whcih we are not funding adequately, I think we

would appreciate knowing about it now rather than have to later state that we were not told of this.

Mr. HORNER. It is my opinion these moneys are adequate in that respect.

Mr. ROUSH. All right.

Do you see any possible way that this Saturn program could be speeded up?

Mr. HORNER. Well, you will note from the schedule which was here on the board that in the process of adding some $90 million to the program in the past month, we have, because of our position in the development, because of the timing of our position in the development, been unable to advance the date of the first launching. This is because we are only something more than a year—a few months more than a year away from that launching. The launching of the 11th vehicle, which was some 5 years away, we have been able to advance a year.

It would be difficult, in Dr. Von Braun's words, to advance the launching of that 11th vehicle any further by adding any more money.

It is possible, I suppose, to assert that we could advance it 1 or 2 months by adding large amounts of additional funds, but I would rather say that the effect of greatly increasing the money to be invested is more likely to improve the assurance of meeting that schedule.

Now, this is a rather obscure factor in any research and development program, since we don't really know how to assess the reliability of the schedule we show you today anyway.

Mr. ROUSH. I was not thinking entirely in terms of money. I must confess I was thinking somewhat in terms of money, but I also had in mind the possibility of the burden of administrative detail slowing this down—the matter of awarding contracts and all of the necessary administration which must go with the awarding of contracts.

In that particular area, could you see any way we might cut across some of these procedures and hurry the program up?

Mr. HORNER. We think we have a pretty good performance in that respect, and it is hard to see how we can reduce the time factors very much.

Let me just give you an example. During the last week in December, after a very comprehensive but short study of the requirements for the upper stages, we identified the general configuration of the upper stages.

In the following month the Huntsville technical personnel, working overtime and working very diligently, wrote the specification for the upper stages and an invitation for proposal which was distributed to industry on the 27th of January.

At that meeting a great deal of discussion with representatives from some 30 companies, I believe, that attended the bidders' conference, stipulated a 5-week period in which industry would have an opportunity to prepare proposals.

These proposals are due to be submitted on the 29th of February.

We expect to take something on the order of a month to evaluate these proposals and select the best proposal, let a contract, and start the development process.

Now this in effect means that a period of about 3 months has been used from the conception of the configuration until the development is under contract.

I think this is an outstanding performance, and I would doubt that any comparable performance could be pointed out in this complex a job.

Mr. ROUSH. I gather, then, you feel that administratively we are proceeding as fast as we could with this program?

Mr. HORNER. I do not see how we could materially shorten that time period, and do a proper job of selecting the best contractor to do this very important job.

Mr. ROUSH. May I ask you approximately how large do you expect this contract to be or is that something I should not ask?

Mr. HORNER. I would rather provide that, Mr. Roush, in a classified document. This again is an area in which we do not want to necessarily bias or handicap ourselves in the negotiation process.

This I know goes back to an earlier comment, an earlier question by Mr. Wilcove, and comments by the chairman.

I think we would find it exceedingly difficult in even providing percentages of total amounts that appear in our budget as to specific contracts because of course these percentages can be immediately converted into actual numbers. I do not think that we attain the best performance in the way of contract negotiation in this kind of an environment.

Mr. ROUSH. I assume it will be in excess of $100 million.

Mr. HORNER. Well, here again, we would have to define what the total time period of the contract is concerned. We expect this to be one of the permanent upper stages for Saturn.

We have plans for using Saturn, assuming a successful development, for some large number of years in our space exploration program, and therefore in selecting this contractor we are in a sense committing ourselves as to that particular source for buying this stage for as long as we are using it.

I would suspect that if we do have a successful development in the Saturn vehicle, then it is a several hundred million dollar contract over a period of many years.

Mr. ROUSH. That is all, Mr. Chairman.

Mr. HORNER. The earliest negotiation, however, will be simply for the development of the stage.

Mr. SISK. Now, Mr. Horner. I know you have nothing to do with executive privilege, but I hope when we request information on this contract after it has been let—I see my good friend Mr. Gleason is back here—we are going to expect to have all the information on how this contract was arrived at. I want to talk to Dr. Glennan about that. This is not trying to put you on the spot, but you know we have not been too happy with the information we received on your last big contract and, of course, I have been looking with some interest at what is going to happen in this one.

I know you are going to do a good job. You are going to give it to the best bidder and the one that will do the best job. I am positive you fellows are sincere in that, but I do hope the committee is given all the information in the manner in which that contract is finally let.

I want to ask you a hypothetical question now. It may be way out in the wild blue yonder. It probably is. But we have been talking now about the Saturn project and we have talked about the F–1. We have gone into that, I think, fairly extensively, and of course we have discussed this Centaur situation pretty well. The Centaur is going to be used to a certain extent very definitely as part of the Saturn, as I understand, or, in a sense, it is going to contribute.

Let me ask you this, then, as a hypothetical matter. Assuming that an unfriendly power or another sovereign nation launches or puts a man into space successfully and recovers him in this coming October, and that next July such power would make a soft landing on the Moon, and with certain other accomplishments that of course would go along with those for a completely successful operation, what would be your position with reference to any possible speedup in any program?

Would you still be satisfied with the schedule as outlined here on Saturn, the schedule which you have given us on F–1, and the schedule on Mercury?

Mr. HORNER. The schedule on Mercury, Mr. Sisk, we could do very little bit about it at that time, because we would be completely committed as far as the hardware and as far as the flight schedules. We would be at that time participating in the flight program.

Mr. SISK. That is right.

Mr. HORNER. Whereas we might be able to accelerate a flight, a month or so. We could do such things as take more risks in accelerating the schedule, but we would have very little opportunity to accelerate the development program at that time in Project Mercury.

Certainly, if we at that time faced the accomplished fact of a man landing on the Moon——

Mr. SISK. Wait a minute; I did not put that in. Let me restate my question.

I stated a hypothetical question, that a man would have orbited the Earth in October of this year and that a soft landing would have been made on the Moon next July. That, of course, our first soft landing, at least we expect our soft landing is going to be strictly instrument, not a man. I was actually going to proceed a little further in my hypothetical case here, I was going to put you a little further on the spot by stating as an accomplished fact a manned exploration of the Moon in 1965, but I was going to let you chew this other around a little bit before we went that far.

If you want to, you can join the issue. But that was actually to put a man in space, in October of this year, a soft landing with instruments and so forth on the Moon next July, and then a manned exploration of the Moon in 1965.

The reason I am using this as a hypothetical question is this. There are many reputable scientists, military people, and others who have actually flatly made this prediction. They believe it can be done; they believe it will be done. I am not saying it will be done.

I hope—and I am not hoping anyone any hard luck; I did not indicate who might do this, I said it might be possible some unfriendly power might do it—I hope, of course, we will be the first ones to land a man on the Moon. I am still hoping we can do the things that will make that possible.

But I do think there is a real chance we might be faced with this. I want to know where then will your priority be. Will it be on Saturn or F–1, or something else. Where is it? I think these things are real serious issues that your agency should be facing up to.

Mr. HORNER. Yes, sir. I think we are facing up to them in terms——

Mr. SISK. I am not saying you are not. I am merely saying this is a toughy and the American people might demand some answers down the line you know.

Mr. HORNER. I would only suggest, Mr. Sisk, it is a speculative question that requires a speculative answer.

Mr. SISK. I appreciate that. I am going along with you on the speculative answer.

Mr. HORNER. I think in the presence of these kinds of accomplishments by the U.S.S.R., and if they are in fact accomplished, the context of our present program, they would have to be accomplished by the U.S.S.R., unless there is a space power we do not know about——

Mr. SISK. That is right.

Mr. HORNER. I question whether we in NASA would be truly masters of our own fate in terms of establishing priorities.

I think we almost certainly would be responsive to the expressed will of the Congress and recognize that it was indeed the expressed will of the American public in changing our program.

Now, as I mentioned earlier, should the Russians launch a man successfully into orbit and return him in October, there would be little that we could do in advancing the development schedule of Mercury, but we certainly would have to recognize the fact that there would be a great deal of pressure on advancing our flight schedule, and one of the possible considerations that would have to be looked at was our assessment of the risk and how it has an influence, because this would be one of the few ways that would be left to us to make any changes in our schedule.

It has been my past experience that accomplishments in the U.S.S.R have reflected on like efforts in the United States. I can go back to experience in the Air Force, for example. One of the first results of the flight of the Bison in the U.S.S.R., I think it was in May of 1955, I might be wrong on the date, was the acceleration in the production rate of the B–52.

People have asked questions why this is so, but it is so, and this has ordinarily been the result.

Now, I think there would be some additional pressure on the rest of our space program from that single accomplishment.

Certainly, there would be additional pressure on the Centaur program with the advent of a soft landing of an instrument package on the Moon in 1961. I believe that was the date that you postulated.

Mr. SISK. Yes, that was my time schedule.

Mr. HORNER. Because it would be with the Centaur that we are developing at that time a capability to have a similar soft landing on the Moon.

As far as the accomplishment of manned flight to the Moon, with a soft landing and a return in 1965, I would suspect that by that time we would be fairly well committed as to the technique in which we were going to attempt such an effort.

We probably would no longer be engaged in a technical debate of whether we were going to use nuclear upper stages, whether we were going to use a direct ascent from the Earth, using the F–1 engine, whether we were going to use a rendezvous technique with the Saturn. I think it is likely we would have largely made that decision and we would be engaged in a program to do it.

If past history is any guide, we probably would have little warning that this would happen.

We would, of course, see some preliminary experiments from the U.S.S.R. Certainly one of them would be the manned orbital attempt.

I think right today we would find it rather difficult to believe the Russians would attempt a man landing on the Moon without orbiting a man first.

Mr. SISK. I could not conceive of their doing that. I am assuming, of course, they are going to proceed more or less in an orderly fashion, as certainly your program, I think, takes steps in sequence. For example, this idea of putting a man in orbit two or three times around the Earth and bring him back.

We find out something about what he is going to be confronted with. Then, of course, as I understand your general program, there follows a soft instrumented landing on the Moon. In other words, not a manned landing, but with manned instruments.

I realize this is hypothetical, and my question is speculative, so your answer has to be speculative.

But we have discussed here to some extent the matter of priorities. I am still concerned about the attitude of NASA, the Department of Defense, the Space Council, and the Security Council, and everyone else concerned with it, with reference to their attitude on the F–1 engine, or the rendezvous technique, or some other technique, for what I hope will be that great long stride which might put us, let's say, again in a superior position in this whole field.

Mr. HORNER. I would like to make one more comment, if I may, Mr. Sisk.

Mr. SISK. Go right ahead. I didn't mean to cut you off, Mr Horner.

Mr. HORNER. In order to accomplish a manned landing on the Moon, it has been our judgment that one of the logical steps on the way, and one of the rather advanced logical steps on the way is to have manned circumlunar navigation and return to the Earth. Because it is with such a mission that we can solve very difficult problems of super circumlunar velocity reentry to the Earth's atmosphere, which we are going to have to solve for this return vehicle from the Moon.

Now, if I were running the Russian program, and I was going to do a manned landing on the Moon in 1965, I would like very much to be able to do this manned circumlunar navigation in about 1962.

We have seen nothing in the Russian program yet that would lead us to believe that the Russians in fact are going to have this capability in 1962.

Now, there are just two further comments. It is very dangerous to base our judgment of the Russian program and its advances on our methodology, because we do not know enough about the Russian program, and it would let you in for surprises to do that.

On the other hand, in response to your statement that many competent people have stated that in their opinion the Russians were going to do this in 1965, and we could do it in 1965, I would point out that they all have one characteristic, and that is, that none of those people have responsibility for performing.

Mr. SISK. I will agree, Mr. Horner.

Mr. HORNER. Therefore, they are never going to be criticized for not doing it.

Mr. SISK. I want to modify one statement I made, so I will be completely clear.

I think the first two things which I mentioned, the man in space, so far as an orbit, and the soft landing on the Moon, I think many responsible people have predicted Russia would do that on the time schedule that I indicated. I will say, I am not too sure too many people have predicted they would put a man on the Moon in 1965. I think probably the period more often mentioned is maybe 1966 or 1967. I believe General Medaris mentioned 1967, as I recall.

But I made the shoe pinch a little bit on the 1965 idea. I frankly think that would be even for Russia a pretty optimistic figure, based on what I understand you people feel to be the normal steps required to ever do this.

Maybe, as you say, we don't want to depend too much on it. Maybe they have other types of steps, I don't know.

Mr. HORNER. There is only one thing we can be sure of, Mr. Sisk, is the same laws of physics, the phyical laws of the universe apply on that side just like they apply on this side.

Mr. SISK. That is one reassuring thing. I appreciate that.

Mr. MCDONOUGH. The other factor is they are devoting their entire—they can divert their entire manpower in the direction of one accomplishment, while we don't. We do many things.

Mr. SISK. Of course they are doing pretty good now at the Winter Olympics in Squaw Valley. That makes me feel a little bad, too. I wouldn't say they are putting it all in one pot, either. I don't like to have everything we do predicated on what someone else does. I have always resented this. I think sometimes to myself, when I attempt to compare it, that I despise this way of having to do things. I don't like to have to predicate everything we do on what someone else is doing. In other words, their calling our shots. I am so desirous of seeing us move out on our own and leave them behind, or somewhere in the dust.

Mr. MCDONOUGH. You don't want to live up to the Jones.

Mr. SISK. I realize as you said on the airplane, sometimes we seem to be a little inclined, of course, to do just what we have to do to stay ahead.

Are there questions? I have taken up quite a bit of time here. Do you have any further questions on the Saturn program?

Mr. RIEHLMAN. No.

Mr. MCDONOUGH. No.

Mr. ROUSH. No, I don't have.

Mr. WILCOVE. With regard to the Russians giving us little warning, I think they have given us considerable warning, if General Medaris is to be believed. He said the Russians already stated they

will celebrate the 50th anniversary of the Communist revolution on the moon, which would be 1967.

Mr. HORNER. There are some 200 million Russians, and there are a large variety of statements that come out of the U.S.S.R. We find that this variety is increasing every day. We do have some communication with the scientific community in the U.S.S.R., and we have a wide disparity in their statements as to what their intent in the space program is. I have not always been able to identify the statements that you refer to as official Russian intent.

Mr. WILCOVE. Of course, I am just quoting General Medaris. I don't know that of my personal knowledge.

Mr. HORNER. I don't know, either.

Mr. SISK. Mr. Hines, do you have any questions?

Mr. HINES. No, sir.

Mr. SISK. All right. I think with that we will conclude today's hearings. I would like to say this before I forget it, and I want to say this particularly to you, Mr. Gleason, if I may, Mr. Wilcove made a request on the breakdown of the $30 million cut in the 1960 NASA budget; specifically how it was absorbed among the various programs. I think that was made several days ago and we still don't have that breakdown. We had hoped to use it here. So, will you get busy and see we get that down here in the next couple of days?

Mr. GLEASON. I think that was delivered to the staff this afternoon.

Mr. WILCOX. We have not received it. I originally made the request to Mr. Ulmer last Friday morning.

Mr. GLEASON. I have a copy.

Mr. SISK. If it is not here get it down to us, Jim, because we would like to have it.

Off the record just a moment.

(Discussion off the record.)

Mr. SISK. We will assume, then, we will meet tomorrow afternoon, let's try to meet at 2 o'clock. We will meet at 2 o'clock tomorrow afternoon, and the committee will reconvene to finish this portion of the discussion.

The committee stands adjourned.

(Whereupon, at 4:35 p.m., the subcommittee adjourned.)

(The information requested is as follows:)

The attached table shows changes in the budget allocations for the NASA research and development budget that have been made to accommodate the funds actually available for fiscal years 1959 and 1960. The table includes revisions in allocations of fiscal year 1959 money although there was no reduction in these funds in the time period of interest. The accommodation of the reduced appropriations for fiscal year 1960 (including the funds requested originally as fiscal year 1959 supplemental) required the changes indicated in the fiscal year 1959 allocations in order to phase all elements of the total research and development program at the best overall pace.

The revised fiscal year 1960 allocations indicate a net decrease of $33,470,000 from the requested appropriation. Of this, only $18,470,000 was a congressional reduction in NASA appropriations below the requested amounts. The remaining $15 million represents a transfer of research and development funds applicable to the manned space flight program (project mercury) to the construction and equipment account in order to proceed with the construction of the Mercury tracking facilities.

It is important that the table be interpreted in its entirety. Changes have been made in almost every allotment title in both fiscal years. This kind of reprograming of funds was necessary to accommodate (a) the reduction in appropriated funds, (b) the transfer of research and development money to

construction and equipment, (c) the transfer of funding authority for certain salary and expense items to the research and development account, and (d) revisions in cost estimates due to changes of scope of work and overruns. The net effect can best be evaluated by examining the last column which shows the net change in the allotment funding for the total 2-year period.

Four allotments show a net increase for the 2-year period. The increase in the support of NASA plant allotment largely represents the transfer of research and development funding of some program items formerly paid under the salary and expense appropriation. Congressional approval was obtained for the transfer of these funding authorities. A lesser part of this allotment change is due to increases in program charges that were underestimated in the original budget requests.

The apparently substantial increase in the lunar and planetary exploration allotment is due to several factors. With the cancellation of the Vega vehicle development it became necessary to program funds into the lunar and planetary allotment to provide for the procurement of Atlas-Agena vehicles to replace the Vega vehicle (formerly, the cost of the Vega vehicles to be used for lunar and planetary exploration were carried in the Vega vehicle development allotment). The remaining increase in the lunar and planetary allotment has been necessary to provide for replacement vehicles and payloads for lunar orbital missions using the Atlas-Able vehicle, for cost overruns in earlier lunar missions, and for the acceleration of spacecraft development for use with the Centaur and Saturn vehicles.

The initial Scout vehicle development program has required approximately a 10 percent increase in funds.

The supporting activities account was increased (a) to accommodate funding of items previously funded in the salary and expenses appropriation and (b) to cover increased data acquisition and data reduction expenses for the fiscal year 1960 space flight program. These latter expenses are a function of the actual flight schedule and hence must be adjusted when adjustments are made in the flight schedule.

In order to compensate for these four allotment increases, and to accommodate the reduction in appropriated funds and the transfer of funds from cost and expense account, it was necessary to make reductions in the large number of allotments. The large reduction in the Vega vehicle development allotment was a result of cancellation of the Vega program and has required a corresponding increase in vehicle funding in the lunar and planetary exploration allotment.

In the liquid rocket allotment there was a reduction of $6 million in the funding of the 1.5 million-pound-engine and an additional reduction in other liquid rocket advanced development of almost $3 million.

The sounding rocket, meteorological, and communications programs were reduced by either a reduction in the number of planned missions or in a stretchout of these missions.

The other allotment reductions were largely in advanced development program areas. The effect of these decreases will not be felt in the immediate or near future flight programs but there may be an effect on programs several years hence caused by this reduced level of effort on new developments.

One special comment is necessary regarding the apparent reduction in the funding of the manned space flight program. This reduction is the result of the transfer of $15 million from the research and development appropriation to the construction and equipment appropriation for the construction of Mercury tracking facilities. In fiscal year 1959, Project Mercury was given a funding increase of almost $9 million over the planned budget. Favorable House action has already been taken on an additional $12,200,000 of supplemental fiscal year 1960 moneys to be applied to this program. Thus the manned space flight program has actually been supported at a level considerably higher than that anticipated in the budget submissions a year ago.

	Fiscal year 1959			Requested	Fiscal year 1960 allocation	Increase (decrease)	Fiscal years 1959–60, net increase (decrease)
	Budget	Allocation	Increase (decrease)				
Support of NASA plant	$588,800	$1,097,651	$508,851	$16,670,000	$22,684,000	$6,014,000	$6,522,851
Research grants and contracts	3,000,000	3,028,000	28,000	5,200,000	4,950,000	(250,000)	(222,000)
Sounding rockets	5,000,000	3,558,170	(1,443,830)	10,000,000	8,811,000	(1,189,000)	(2,632,830)
Scientific satellites	23,252,000	21,305,114	(1,946,886)	22,800,000	23,813,000	1,013,000	(933,886)
Lunar and planetary exploration	25,511,750	31,882,607	6,370,857	14,681,000	49,000,000	34,317,000	40,686,857
Meteorology	2,500,000	987,550	(1,512,450)	10,800,000	7,930,000	(2,870,000)	(4,382,450)
Communications	3,450,000	3,574,806	114,806	4,700,000	3,170,000	(1,530,000)	(1,415,194)
Manned space flight	37,661,200	46,416,333	8,755,133	90,750,000	74,962,000	(15,788,000)	(7,032,867)
Vehicle systems technology	1,000,000	1,903,651	903,651	10,330,000	6,737,000	(3,593,000)	(2,689,349)
Solid rockets	700,000	615,898	(84,102)	4,785,000	3,785,000	(1,000,000)	(1,084,102)
Liquid rockets	17,000,000	15,978,589	(1,021,411)	38,188,000	30,328,000	(7,860,000)	(8,881,411)
Nuclear systems technology	4,500,000	3,810,496	(689,504	8,000,000	6,000,000	(2,000,000)	(2,689,504)
Space power technology	800,000	0	(800,000)	6,314,000	4,814,000	(1,500,000)	(2,300,000)
Scout vehicle development	6,048,000	6,048,000	0	2,000,000	2,800,000	800,000	800,000
Delta vehicle development	13,800,000	12,927,417	(872,583)	13,300,000	13,300,000	0	(872,583)
Vega vehicle development	22,800,000	14,291,494	(8,508,506)	42,800,000	4,000,000	(38,800,000)	(47,308,506)
Centaur vehicle development		4,000,000	4,000,000	41,000,000	37,000,000	(4,000,000)	0
Supporting activities	3,300,000	3,095,674	(204,326)	11,500,000	16,266,000	4,766,000	4,561,674
Vanguard	25,541,282	21,943,582	(3,597,700)				(3,597,700)
Support of JPL plant	8,156,500	8,156,500	0				0
Total	204,619,532	204,619,532	0	353,820,000	320,350,000	(33,470,000)	(33,470,000)

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1961 NASA AUTHORIZATION

WEDNESDAY, FEBRUARY 24, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE No. 4,
Washington, D.C.

The subcommittee met at 2:20 p.m., Hon. B. F. Sisk (chairman of the subcommittee) presiding.

Mr. SISK. The committee will come to order.

We will take up the consideration of the program on tracking and data acquisition. The overall figures in this particular section are $32,550,000 as compared wtih last year's figure, or at least the present fiscal year, of $16,266,000. In other words, we are considering almost exactly double the amount of money requested in the previous fiscal year.

Mr. Horner—or either of you gentlemen—if you want to make some comment on this backup material we will be happy to have that, and then we will proceed with any questions which we may have on the particular items.

Mr. HORNER. I might point out just as a general statement, Mr. Chairman, the increase in funds required for the support of the tracking and data acquisition is a direct measure of the maturity of the program. This, of course, is the money required to gain operational utilization from the vehicles, and it reflects the increase in space operations.

Mr. Wyatt here will give a brief statement in support of this account.

STATEMENT OF D. D. WYATT, ASSOCIATE DIRECTOR OF PROGRAM PLANNING AND COORDINATION, OFFICE OF SPACE FLIGHT PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. WYATT. Mr. Chairman, as Mr. Horner points out, the growing amount here is an indication of the maturing of the NASA space program, and in particular reflects the coming into rather full operation of the several kinds of tracking networks that we find necessary to track, collect data, and analyze data from our various space activities.

I believe that the clearest picture of the contents of this particular allotment can be obtained by going down first to the flight research program, and then coming back to the advanced technical development.

Our flight research program, the elements so indicated here, resolve themselves in sequence. First, the cost of operating what we call our satellite stations. This is primarily our minitrack network, a network of some 14 interferometer stations located fairly well throughout the world, although substantially the majority of them are on a single longitude running through North and South America.

You may recall this was the network originally a part of the IGY to track what we call the low inclination orbit satellites, and also to receive data from these satellites.

You may further recall that the last session of Congress funds were appropriated for the construction of four additional of these stations to give us an ability to catch north-south passes as well as east-west passes.

The sums indicated here, $5,600,000, are for the operation of these stations, which is done by contract, and for the data transmission from each of these stations back to what might be called a data central to be located at the Goddard Space Flight Center at Greenbelt, Md.

These represent the line charges for the communications system that is used, and the personnel and operating expenses in support of these 14 stations.

There is also a small sum in here for partial operation of what are known as microlock stations, that were part of the ABMA vehicles, the Redstone and Explorer vehicles launched by ABMA.

Now, the second item here is for the operation of optical tracking stations. Substantially the same kinds of items are requested here, a sum of $1,950,000 for the actual operation and payment of personnel for these so-called Baker-Nunn stations.

These are very precise optical equipment that can give us the finest fix possible at the present time on the actual position of a satellite in space. This is very important for precise orbital determination.

Mr. SISK. Could I ask a question right there for clarification?

These are figures that are used in the research and development part of this budget request. I was curious about any duplication. We have salaries and expenses section of this budget, which of course is handled by another subcommittee of our committee; you mention now salaries and expenses.

Mr. WYATT. Mr. Sisk, these salaries and expenses I refer to here are for contract personnel. For example, in the case of the Baker-Nunn stations, the contractor is with the Smithsonian Institution. They actually operate it. I am referring to the bulk of the money which is to pay the people who actually man the stations, but are not civil service employees of the Government. They are contract employees assigned to these station operations.

Mr. MCDONOUGH. On a contract basis, are they year-round contracts, or are they just contracted for tracking a particular satellite?

Mr. WYATT. No; a year-round contract. We have so much stuff in the air that these stations are continually busy. They are receiving and tracking—I can't give you an exact number—but many more than a single satellite at a given time.

Mr. MCDONOUGH. Let's follow that for a minute.

What is the oldest satellite we have in orbit at the present time?

Mr. WYATT. The Vanguard I.

Mr. MCDONOUGH. How long has that been flying?

Mr. WYATT. That has been flying since January 1958.

Mr. MCDONOUGH. They are tracking that every 24 hours; they are tracking that every time it comes around?

Mr. WYATT. I can't say with assurance they keep a precise track on it. The orbital elements on that have been well enough established that they may take periodic data from it, because they can predict where it will be.

Mr. MCDONOUGH. Are the instruments still operating in Vanguard I?

Mr. WYATT. Yes; the transmitter is still functioning.

Mr. MCDONOUGH. Isn't the information, now obtained that it has been operating for quite a long time, more or less a duplication of what was previously received, or is there something new?

Mr. WYATT. It is new in the sense that the effect of time variables—in other words, the different state of solar activity as it affects energetic particle distribution, for example, the effects of seasonal changes, annual changes—there is much we don't know about the surrounding atmosphere.

Mr. MCDONOUGH. You mean the satellite will pass a particular station at a different time of the day?

Mr. WYATT. Well, there are a number of stations. There are 14 stations involved that can collect data from this particular satellite.

No; what I mean is, the data that the satellie collects, he let us say today, may be of scientific significance because it may differ in the strength and content of the energetic particle field from what we measured a month ago or 6 months ago or a year ago.

This becomes an instrument that as often as we choose to sample it, shows us what is the changing flux of this field, and then we relate this with other measured physical phenomena and try to get a better understanding of just exactly what is this field that this is measuring.

We don't really know too much in truth about these energetic particles, what is their real source, that is. We are beginning to get a good feel, but we don't know exactly what is the real source and what affects them.

Mr. MCDONOUGH. That is Vanguard. How many others do we have that are operating?

Mr. WYATT. I am afraid I can't give you an exact count—is it five?

Mr. MCDONOUGH. We have five operating.

Each one of them is equipped with instrumentation that will give us different data; certainly we don't have two of three satellites for the same?

Mr. WYATT. There are a number of satellites, five satellites up. I believe Explorer VII is the only one actually transmitting at the present time, except for Vanguard I.

I believe there are just these two. Explorer VII will be transmitting for approximately another 9 months if it goes according to schedule.

Mr. MCDONOUGH. What have we found out from a digest of this material? We certainly have had a chance to evaluate some of this material by now?

Mr. WYATT. Yes, sir. This is a very broad question, and can't give you a simple answer. But I will point out such things as this:

This initial Vanguard discovered what we now know as the "Van Allen belt," or the "great radiation belt," and the data from that were used to draw certain conceptual pictures about what this belt was: It was a doughnut of a certain size and certain intensity of radiation of energetic particles.

Subsequent experiments with subsequent satellites and with the space probes determined that we were only measuring part of the energetic particle fields in this Vanguard I measurement, that in truth what at that time appeared to be a rather well-defined radiation belt was a part of a large zone of intense radiation of many kinds of particles.

The experiments——

Mr. McDonough. These are particles. When you speak about particles, are you talking about meteorites?

Mr. Wyatt. No, sir, I'm talking about the very basic particles, of hydrogen particles and electrons, the very basic building blocks—that kind of particles—that are continually bombarding the earth, probably from the sun for the most part.

Mr. McDonough. As a result of that information, have we changed the design, or does it have any effect on the design, of Mercury?

Mr. Wyatt. It has not had any effect on the design of Mercury, because Mercury if flying below the lowest level that any of these belts have been measured to have any intensity.

It is, however, beginning to have an effect on our thinking about what kind of a shielding we will have to put on a manned vehicle that will penetrate as far as the Moon, for example, or that will fly substantially higher than Mercury.

If we talked about flying a vehicle 10,000 miles above the Earth, the information that we are collecting, and that is being refined with each one of these flights, and on a time basis, is the kind of information we have to have to know how thick a shielding we need to put around the man in this.

Mr. McDonough. Our minitrack stations can also track foreign satellites, can't they?

Mr. Wyatt. If they are at the frequencies the minitrack stations are equipped to handle.

They are now being converted and within about a year I believe will be wholly converted to a new frequency band around 135 to 136 megacycles.

Mr. McDonough. Do you know how many foreign satellites are now flying?

Mr. Wyatt. Well, there are no active ones to my knowledge. That is, no active transmitting.

Mr. McDonough. That means we are getting more information about outer space conditions more frequently than Russia is?

Mr. Wyatt. Yes, sir.

Mr. McDonough. Still, they are considered to be further advanced in design than we are for man-in-space and other things. They are certainly not getting the information we are getting, are they? Are they getting our information, too?

Mr. Wyatt. Sir, I don't know myself whether they are further ahead in the ability to put a man in space or not. I think it would be conjecture. We don't know. At least, I don't know what the exact state of their technology is.

Mr. Wilcove. Mr. Wyatt, in further response to Mr. McDonough's question, though, are they getting the information we get?

Mr. McDonough. In other words, are they benefiting by our minitrack stations?

Mr. WYATT. The scientific information, yes, is being released to the world data centers through the National Academy of Sciences. They, in turn, release back data that they obtain, and we have access to that data.

Mr. MCDONOUGH. However, do they have active satellites at the present time?

Mr. WYATT. No, sir. Volumewise we have accumulated much more data.

Mr. HORNER. Their contribution of scientific data to the World Data Center has been much lower than ours.

Mr. MCDONOUGH. In other words, we are spending money to give them information that would be valuable to them in exploring outer space?

Mr. HORNER. Yes, and I think it is accurate to say, Mr. McDonough, that contrary to the commonly held public opinion as regards the relative prestige of the space programs of the U.S.S.R. and the United States, in the scientific community of the world, it is widely acknowledged that our program has been much more productive than that of the U.S.S.R.

Mr. MCDONOUGH. I have always felt so, and am more or less convinced that that is true.

However, in our attempt to accomplish what we are hoping to accomplish in this whole program, we are providing them with information that will be beneficial to them.

I don't want to belabor this point, Mr. Chairman, but it is information that I think is essential to this part of the budget.

In interpreting this information, Mr. Wyatt, you get this back in a dot-and-dash system, don't you? How do you get the electronic impulse recording on a minitrack station?

Mr. WYATT. Well, it comes back in an electronic code, and it is recorded on tape, on a magnetic tape. It is more often a frequency variation, for example, than it is a pulse.

There are a variety of forms in which it can be transmitted.

Mr. MCDONOUGH. And that can be translated into temperature—and what other things are we looking for?

Mr. WYATT. Well, for example, in the energetic particles we can have a counter like a Geiger counter, for example, that measures impacts of these particles, and is so designed that after it measures a certain number of impacts, it sends out an impulse so we know there is a certain count.

By arranging the transmitter circuit, you can get this as a gross count or fine count, depending on what it is you are trying to measure. Each time it accumulates a certain count it sends out a signal. This is one way of doing it.

So we can count things, we can measure temperatures—well, what we do in all cases is——

Mr. MCDONOUGH. Volume, I suppose.

Mr. WYATT. We—in all cases, whatever it is, we are changing it to an electrical signal of some sort, we transmit that electrical signal and then we translate it back through calibration into the original parameter that we measured.

Mr. MCDONOUGH. This is a new part of the art, isn't it, a minitrack station? This is something that we have known about for many,

many years, isn't is? When we first put up our first satellite, were we equipped to track it?

Mr. WYATT. Yes, sir. These stations were built as a part of the anticipated satellite flights and tracking for the International Geophysical Year.

Mr. MCDONOUGH. Previous to that, these stations were not in existence?

Mr. WYATT. That is right.

Mr. MCDONOUGH. So that is only 2 years old, isn't it?

Mr. WYATT. Two or three, yes, sir.

Mr. MCDONOUGH. Two or three?

Mr. WYATT. Yes, sir.

Mr. MCDONOUGH. So it is an experimental part of the art?

Mr. WYATT. We consider the minitrack stations themselves to have moved beyond an experimental part of the art as far as normal tracking operations are concerned.

We do have moneys in this budget under Advanced Technical Development that are designed to enhance the efficiency and data collection capability of the minitrack stations.

In other words, they are not a finally developed state of the art, but they are a useful day-to-day working tool now. We are seeking ways to make them even better.

Mr. MCDONOUGH. That is all for the present, Mr. Chairman. I would like some detail on this.

Mr. SISK. That is fine. Go right ahead. That is what we want to do, to explore these subjects as much as we can.

Mr. HORNER. I think it might be well to point out the dissemination of this information to the World Scientific Community is in accordance with our responsibilities as reiterated in the National Space Act of 1958, and directly responsive thereto.

Mr. MCDONOUGH. I realize that we are very generous in that respect, insofar as the original act is concerned. Which other nation is very interested in our satellite data besides Russia, if you know?

Mr. WYATT. There are a number of nations that are interested in becoming participants in the space program. There are none that are in the space program as we conceive it, that is, in terms of very high altitude sounding rockets and satellites. The Japanese, I believe, have a rather intensive low altitude sounding rocket program going. The Canadians are participants there, the British, and the Australians.

I am not qualified to enumerate all of them.

Mr. HORNER. I am qualified, I think, to say that the scientific community, as distinct from the governments, of every civilized nation in the world, has a very real interest in data from these experiments.

Mr. MCDONOUGH. Well, now, on that basis, wouldn't it be proper to make an approach to these nations to ask them to participate in financing these minitrack stations? The burden of obtaining this information is largely on the United States. If this program is for civilian exploration of outer space, for peacetime purposes, why shouldn't there be an international fund for accomplishing this instead of the whole burden being assumed by the United States?

Mr. HORNER. Mr. McDonough, we do and have approached other nations to participate in the space program, and we have had ex-

pressions of interest from many other nations, and some of them are participating to the extent of spending national funds in the program.

It is very impractical, however, to depend on other nations to support with their financial resources a thing that is so essential and so necessary to a schedule as a tracking station.

For one thing, the physical geography of the world is such that we want these stations in many cases located in countries that do not have the capability of supporting it.

Mr. McDonough. With regard to the location of the station, I would agree. But, the maintenance of the station, it seems to me, should be a participating responsibility of the nations most interested in the data that will be obtained.

Now, Russia, of course, is the principal nation, I believe. For instance, I don't know what their minitrack station system consists of around the world. But the U.S.S.R. nevertheless, when it shoots a satellite up, has minitrack stations some place to catch this data, doesn't it?

Mr. Horner. In this respect we have a very real advantage over the U.S.S.R. They do not have land-based tracking stations outside of the U.S.S.R.

Mr. McDonough. Oh, I see.

Mr. Horner. To our knowledge, unless they have been able to hide them from us. That is very unlikely, except there has been speculation that they might have one in Antartica, for example. We consider that unlikely.

The question of where the stations are located, however, are necessarily related to their financial support. It would be extremely difficult, for example, to expect the British to support a station that is located in South America, because the British have very real requirements for the resources they have been able to make available to the space program in other elements of our space program.

What I'm really saying here is that we find it more advantageous to accept and cooperate with the support of other foreign nations in other aspects of our program, rather than in the tracking and instrumentation, and I think we jointly get more out of cooperation in other areas.

Mr. McDonough. Just one final question, then I'm through on this point.

With the broad system of minitrack stations we have around the world, if we can tune in on the signal of a Russian satellite, we can get more information from that Russian satellite than Russia can, can't we?

Mr. Horner. In terms of its total flight time, as the Earth turns under a space probe, for example, the Russian land mass is such that it covers not quite half of the world.

Mr. McDonough. That is north and south, or east and west?

Mr. Horner. That is east and west, and that is the way the Earth rotates.

Mr. McDonough. That is right.

Mr. Horner. There are some differences in our capability. I will make one correction. It is not feasible in most respects to use the minitrack stations for that purpose.

Mr. Wyatt is coming to another category of stations here which can be used for that purpose. The minitrack stations are so designed they cannot readily change their frequencies.

Mr. McDonough. OK.

Mr. Sisk. At this point does the gentleman from Indiana have any questions?

Mr. Roush. No.

Mr. Sisk. All right.

Go ahead, Mr. Wyatt.

Mr. Wyatt. If I may proceed, I have been describing the operations for the funds for the operation of the minitrack satellite stations and the optical tracking stations, both of which are used to track Earth satellites.

Now, the next item in our program are funds in the amount of $3½ million for the operation of what we call deep-space stations. These refer, Mr. McDonough, to the area that you were just discussing.

These are the stations which track the probes out to the Moon and beyond. They differ rather markedly physically from the minitrack stations because the signals they have to receive are very, very faint because of the very long distances of transmission, and hence these are the very large radio dishes, so-called. The particular network that we have uses dishes 85 feet in diameter, which can be pointed at any sector or point in the sky that they can see.

Our total network is not yet completely in operation. We have a station at Goldstone, Calif., which is our principal station at the present time.

We have one in Woomera, Australia, that will be going into operation here very shortly.

And a third station will be in operation in about a year in South Africa.

Now, these three are located around the Earth such that when we send a probe off into space, say to the Moon, or beyond, as the Earth rotates, one or two of these stations will always be able to see—literally see the probe—and hence we can get a continual data reception from them.

Now, since we only really need three of these stations, because we can put them approximately 120° apart, and after the probe gets a few thousand miles from the Earth we can always see it then. So this is what constitutes our deep-space stations.

Again the moneys here are broken down into the operating moneys required for each one of these three stations, and for special equipment that are required, including data transmission links back to the United States.

Now, the next item is for the operation of our Mercury net stations. The Mercury, of course, is a satellite of the Earth, but as was pointed out, I believe by Major Hammond, in a discussion before the full committee, Mercury has some very special characteristics that make it impossible technically to track it satisfactorily with the Minitrack network.

Mr. McDonough. When you say a satellite of the Earth, you mean from a station as distinguished from a deep-space probe?

Mr. Wyatt. Yes, sir. Mercury is only going to go in orbit for about 4½ hours. Because it contains a man, it is necessary to know

very accurately and very instantaneously exactly where this is at all moments of the flight.

Now, these kind of data cannot be obtained rapidly from our minitrack system. It actually requires perhaps 8 hours to get a full and accurate orbit determination of a satellite tracked by minitrack.

The whole Mercury flight from beginning to end will only last about 4½ hours. Hence, we are putting into operation a semipermanent network that we will call the Mercury net. It is about 18 stations, including the control center at Cape Canaveral, and the control center at Goddard, especially equipped to handle this very special case of a low altitude satellite that must be tracked instantaneously and very precisely throughout its entire flight path.

Now, the "funding" indicated here is only the funding for the transmission of data from these Mercury stations back to the central control points. The remaining operating costs of the Mercury networks are funded under the man-space flight program, because they can be uniquely identified as part of the costs of the manned space flight program, whereas the minitrack and deep space network service a large number of programs, and hence we can't allocate their operating expenses against any particular one.

So, the $5,450,000 indicated here for the operation of the Mercury stations is actually only for the data transmission links—the cables and radio networks required to bring this data back to the central data points in the United States.

Now, in addition to these networks, which are NASA-owned and operated under contract, we also find it desirable and important to supplement our data collection with other equipment from time to time.

For example, I indicated at the present time that we have in our deep-space net only the Goldstone station actually operational. Hence, when we make a deep-space probe at the present time, we can only see it part of the time, approximately a third of the day from the Goldstone station, and it would be out of sight the other two-thirds of the day.

There is a sum indicated in this budget in the amount of $300,000 for funds for the Jodrell Bank radio telescope operated by the University of Manchester in England; in other words, we utilize that telescope to supplement the Goldstone telescope and give us a greater coverage at the present time.

Mr. McDonough. When you say in sight, you mean in physical sight?

Mr. Wyatt. In physical sight, because these radio frequencies can only be picked up on a direct line of sight. They are like FM or TV transmission, for that frequency range.

So we have in here a sum of money, $300,000 for the utilization of the services of the Jodrell Bank telescope as part of our deep-space operations.

Mr. Sisk. Could I ask you a question?

Mr. Wyatt. Yes, sir.

Mr. Sisk. This is in connection with the line of questioning followed by my colleague from California a little while ago.

England, of course, is interested in the space program, I know. It is doing quite a bit of work in this.

I assume, of course, that the Jodrell Bank Observatory, which is basically financed by the British Government, is fully cooperating, this $300,000 is only a very small portion?

Mr. WYATT. Yes, sir.

Mr. SISK. To what extent is that a portion of the cost? The point I am thinking of is this: It would seem to me the British are getting all the information we get. I am just curious to know the extent of cooperation here, even with Fort Churchill in Canada, for example, which you are going to touch on apparently next, and particularly those stations in the British Commonwealth.

I am curious to know to what extent these countries cooperate in the cost of any of these programs. I don't want to throw you off on this discussion and get too far afield here, but I do think Britain certainly is involved.

Mr. WYATT. Yes, sir. May I answer it this way?

The sum of money in the support of the Jodrell Bank telescope is more than a token sum, it is not however, I think, the full value by any means of the services that we get from the Jodrell Bank telescope.

It is actually a sum estimated from requirements for the tracking of a certain number of either peculiar satellites or space probes for a certain estimated number of days throughout the year.

But it is not the kind of an expenditure where they would bill us exactly, "we put in so many man-hours today and we send you a bill for it." It is a mutual estimate of what we consider a fair share of the costs.

You see, really, the telescope is not designed for these purposes at all. It is an astronomical telescope, and we divert it from the normal astronomical—radio astronomy usages, when we ask them to apply it to the tracking of our vehicle.

So this is a sum that is mutually agreed at as reasonable, but it is not a precise billing, and we feel that we probably get far more service than is represented by the dollars here.

Mr. HORNER. It, in effect, in both the case of Jodrell Bank and for the Churchill, is a sum of money which makes their facility available to us on our schedule as opposed to the schedule that would be demanded by their ongoing program.

Mr. WILCOVE. Do you know whether Jodrell Bank is receiving funds from any other American agency?

Mr. HORNER. Jodrell Bank in the past has received funds from the Air Force. However, it is uniquely a deep space device, because of tracking rates that are permitted and its capabilities.

Since the deep space exploration function has been entirely within the NASA responsibility, all of the support of Jodrell Bank in that activity has been supported by NASA.

Now, as Mr. Wyatt mentioned, Jodrell Bank was—the scope was originally designed as a radio astronomical device, and I'm not sure they may not receive funds from the National Science Foundation, for example. I just don't know.

Nobody else in the United States is paying them for support of the space program.

Mr. SISK. Go ahead, Mr. Wyatt.

Mr. WYATT. The chairman raised a question regarding Fort Churchill in Canada. This is a little different arrangement. This is a sharing of the cost between the Department of Defense and the NASA for maintaining this base at Fort Churchill, which we use in our sounding rocket program, which has special equipment for the sounding rockets. It is an advantageous site, scientifically speaking, because it is near the magnetic pole, and allows us to penetrate into the auroral zones, where there is a certain focusing of the magnetic fields, and consequently the particles tend to be peculiarly focused at that point. It is a very attractive scientific site for the study of ionospheric and energetic particle areas.

The sum here is arrived at by agreement between the Department of Defense and the NASA on the sharing of expenses for the maintenance of that base.

Mr. SISK. Why did it go up $50,000?

Mr. WYATT. This is an estimate that the operating costs will go up slightly.

Mr. HORNER. It is an estimate based upon the projected number of flights, number of experiments out of Fort Churchill.

Mr. SISK. Is that the reason why our payment at Jodrell Bank went up from $200,000 in fiscal year 1960 to $300,000 in fiscal year 1961?

Mr. WYATT. That is based on an estimate of the number of flights we are going to ask them to track, and the duration of time we will ask them to do tracking. It is related to the flight schedules in both places.

Mr. MCDONOUGH. Mr. Chairman.

The largest increase is for "All other." What does "All other" mean?

Mr. WYATT. Well, these are for other tracking facilities throughout the world. The reason for the very large increase here is we will be getting into operation with our meteorological satellite Tiros in this coming fiscal year, and in order to supplement the tracking facilities to give us the optimum data coverage with the Tiros satellite, we found it desirable to set into motion several stations, special stations, actually operated by the Signal Corps.

And this is our share of the expenses of operating the stations at Deal, N.J., and at Kaena Point, Hawaii. That is the primary reason for the increase in this particular item.

This program has not reached the active flight stage, or will not until fiscal year 1961. We have not yet used these stations.

Mr. SISK. Right along that same line, going back just one jump there, to the operation of Goldstone. For example, in fiscal year 1960, you are apparently using $1,400,000, and you are only requesting $1,250,000 in the coming year.

Why, in view of your stepup in programing, did your costs for Goldstone in California go down?

Mr. WYATT. Primarily because these sums include not only the costs of personnel operations, by contract, but also certain special equipment that are added to the station from time to time.

I do not have a list, but in fiscal 1960 we had some special equipment costs that are not reflected in the fiscal 1961 budget. Hence the actual sum involved in the operation of the station, including special items of equipment, is a little lower.

Mr. HORNER. The original construction of these stations, Mr. Sisk, is out of the construction and equipment allocation. After the station is constructed, minor modifications and equipment additions come out of the "Research and development" account. This is the reason for the fluctuation in the "Research and development" account.

Mr. SISK. That is what I was trying to get clear in my mind all the time. Of course, this budget has the construction and equipment request in a completely separate section. Salaries and expenses are over in another separate and complete section. Still, to a certain extent, we are dealing here with what in essence are salaries and expenses, and to some extent equipment, are we not?

Mr. WYATT. What we call minor equipment, yes, sir.

Mr. SISK. It is a little difficult to understand?

Mr. WYATT. I can assure the chairman in arriving at the cost estimates, it does not reflect a reduced use rate for Goldstone during 1961.

Mr. SISK. Go right ahead, Mr. Wyatt.

Mr. WYATT. Well, proceeding down, we have $2,100,000 in here for operations at the Atlantic Missile Range and Pacific Missile Range stations. These are to cover special costs incurred in the support of our program that are frequently chargeable to the programs and are not borne by the Atlantic and Pacific missile ranges as a part of their general overhead account.

There are quite a variety of these things. Special equipment usage that we have to have, special airplane uses for tracking, for checking out some of our equipment, the use of some of the special telemetry ships on certain flights, the fuels that we use in our missiles.

And there are in these accounts some minor modifications to equipment, where we actually modify equipment owned by AMR or PMR. We pay for that modification if it is peculiar to our own uses.

These sums taken together represent our estimate of these expenses during fiscal year 1961.

You will notice that in both AMR and PMR there are increases over fiscal 1960. This again reflects the greater activity level of the flight program in this forthcoming fiscal year as compared with the one we are in now.

Mr. SISK. Let's take the $1½ million allocated to the Atlantic Missile Range. Does the majority of that go to Pan-American Airways under its contract?

Mr. WYATT. No, sir, not to Pan Am. I can give you just as a general idea, about a little over a fifth of this will be for propellant charges. We will pay this to the Atlantic Missile Range in return for the fuel and oxygen they supply to us in our vehicles.

Mr. SISK. It is my understanding that Pan American is operating the Atlantic Missile Range, aren't they, under contract with the Federal Government?

Without intending any criticism, I was curious to know if basically this sum will be paid by NASA to Pan American in the overall operation? Or, are these funds going specifically to the Air Force, let's say, or to some other branch of the military service in payment for something it has done, and, in turn it, pays Pan Am?

I am trying to trace how these funds are handled.

Mr. HORNER. Pan American under contract with the Air Force has the responsibility of operating the Cape Canaveral downrange stations.

Mr. SISK. Right.

Mr. HORNER. This does not provide for logistic supports for the research and development operations, for example. It does not provide for unique ground servicing equipment requirements.

Most of our money is in these categories, and therefore I think none of the money that we are talking about here goes to Pan American. It goes to—some of it, to other contractors.

There is a big fraction of it that goes for the payment of propellent charges, which we will contract for through the Air Force supply system at Patrick Air Force Base.

Mr. RIEHLMAN. Could I ask what would be the number of personnel involved in this operation? Do you have any idea, in the Atlantic Missile Range, the number of personnel?

Mr. WYATT. As a whole, for the whole range?

Mr. RIEHLMAN. Yes.

Mr. HORNER. I'm sorry, Mr. Riehlman, I did know but the number slips my mind.

Mr. RIEHLMAN. Is it a sizable number?

Mr. HORNER. It is a very large operation.

Mr. RIEHLMAN. Is that included in the $1,500,000?

Mr. WYATT. No, sir. This does not go to pay the ordinary operating charges of the Atlantic Missile Range. That is funded by, I presume, the Air Force budget.

Mr. HORNER. We do not reimburse the Department of Defense in any way for the normal day to day operation of the Atlantic Missile Range. This does appear in the Air Force budget.

We pay only for those charges that are unique to our program that are peculiarly there because of a specific launch operation that we have.

So we do not pay for the total personnel complement of Pan American, for example.

Mr. RIEHLMAN. But NASA does have some personnel there at the Atlantic Missile Range?

Mr. HORNER. We have assigned a small number of liaison personnel there as liaison to the Atlantic Missile Range, and of course when we take responsibility for the Huntsville group, we will also have at that time assigned to us the Missile Firing Laboratory, the personnel of which are largely located at the Atlantic Missile Range.

Mr. RIEHLMAN. Well, would that cost be reflected in this $1,500,000?

Mr. HORNER. No, sir, the cost for those people are in salaries and expenses. They are direct employees of NASA.

Mr. RIEHLMAN. So this is for propellant——

Mr. WYATT. I have a listing of typical items here. I might read them.

Propellants.

Such small items as telephone toll charges that were included.

Overtime pay for certain civilians. This comes about because in our base charges, we are charged by the Ballistic Missile Division, for example, for a missile launched. We pay them for the missile up in the air. But if for one reason or another we have to hold a parti-

cular phase of a launch over a certain number of hours, then of course a number of people have to go on overtime pay, and we pick this up as a special charge. In other words, it is not included in this base figure that the Ballistic Missile Division is able to quote us on the missile.

Travel. Special travel by arranged personnel in support of the NASA program. That is a fairly small item.

Then we have a fairly sizable one for Military Air Transport Service flights in support of our activity at the range.

Equipment modifications, which we have discussed. Special equipment modifications to the range.

And then general contracts for various services that we lay on the range that are peculiar because we are there and they wouldn't have if we weren't there. This might be special computer charges. Where we asked them to provide us with special computer service as a part of the launch that they would not otherwise have to provide, then we directly reimburse them.

But in none of this is there day to day routine operating expense involved.

Mr. RIEHLMAN. You have an increase of over a million dollars over the fiscal 1960.

Mr. WYATT. Yes, sir.

Mr. RIEHLMAN. That, you say, is due to the increased activity.

Mr. WYATT. Yes, sir.

Mr. RIEHLMAN. On the range?

Mr. WYATT. The number of flights we will be making out of AMR, as compared with fiscal year 1960.

Mr. HORNER. Very substantially, Mr. Riehlman, this reflects the increase in tempo on Project Mercury, because during this particular time period we have a very concentrated firing schedule on Project Mercury, and it of course, because of the man, is unique in many respects as far as the range operation is concerned.

Mr. RIEHLMAN. That is all, Mr. Chairman.

Mr. SISK. How many launches do you propose to make from Vandenberg. You have tripled the expenses on that range. Is NASA going to make some shots out there?

Mr. HORNER. In general terms, we will use the Pacific Missile Range for all launches which require polar orbits.

Mr. WYATT. Specifically during this coming year, sir, we will have several shots of the smaller sounding rocket kinds of vehicles from PMR. We will be readying facilities at PMR for use of the Delta vehicle that will not actually be fired during fiscal year 1961, but we will be installing special equipment in preparation for the Delta flights.

Much of the PMR operational cost here is in equipment being installed for flights that will actually take place in 1962, a lesser part of it for the actual or specific flight operation there.

We will have at least four sounding rocket flights from that site in this time period.

Mr. SISK. Okay, go ahead.

Mr. WYATT. All right.

We come down next to an item, our station at Wallops Island, transmits or will transmit its data to the Goddard Space Flight Center for central data reduction.

We have an item in here for the transmission of data from Wallops Island to Goddard. Then we have special data reduction services at the site down there.

These are actually not related to—I shouldn't identify them as part of Wallops. These are data reduction services that are in excess of those provided at the Goddard Space Flight Center.

In other words, we will be using our own computers at the Goddard Space Flight Center substantially on the data reduction from the flight program.

We will find from time to time that this equipment is not enough to handle all of the flights, all the data coming in simultaneously. We will have to use other computers in the area, and we will also have a certain load of theoretical computations of orbital calculations and this sort of thing not related to a specific flight so that we will have to supplement the computers of the Goddard Space Flight Center.

We estimate this $800,000 to be the cost for other data reduction services than those that we provide in-house.

Mr. SISK. To make a comparison, then, this $2¼ million——

Mr. WYATT. Yes, sir, I should note that, sir. The $2¼ million is because this fiscal year we are operating the Vanguard Computing Center on Pennsylvania Avenue under contract.

We are installing our own computers that we will have in operation at Goddard in fiscal year 1961, so we will not be paying the contract operating cost on the Vanguard Computing Center. This accounts for the reduction in this particular item between 1960 and 1961.

The last item back here in the flight program is for network maintenance and repairs and network spares and materials.

These are estimates, rather conservative estimates, based on what it will take to equip or maintain and repair the sum total of about 40 tracking stations. To sum up all these stations, the minitrack, the optical stations, the Mercury stations, and the deep-space stations, this is an estimate of about a little less than $4 million required in the way of maintenance and repairs, including spares and materials for all of these stations.

Now, if I may, I wiuld like to go back—I did not discuss the advanced technical development area, which amounts to $7,220,000 for 1961.

This is for research and development, and the development of specialized equipment that will in the future make our tracking systems improved over where they are now.

For example, we have a special problem at the present time. We can send a time signal to our stations throughout the world with an accuracy of about two thousandths of a second. In other words, we can give them a standard instantaneous time within about two thousandths of a second. This is because a signal passes through a number of channels, a number of pieces of electronic equipment.

This is pretty good if you are trying to keep an appointment, but it is not nearly accurate enough, by perhaps, we need 10 times this accuracy, in order to calibrate all the stations and know instantaneously where the satellite is at the time we take data. In other words, to give

them a very exact time calibration, so that we can calculate the orbit very precisely.

We have considerable amount of research and development planned in trying to improve the time accuracy so that we can transmit a signal around to all of these stations so that we can get improved orbital calculations.

The computer out here at Goddard will be going into operation, and is going to have to handle a tremendous amount of data.

Just reams of data comes forth from each one of these satellites, and as time goes on we are going to have more and more simultaneous satellite flights.

We want moneys to study how we can best utilize the data, or utilize the computer to reduce these data. It means mechanizing processes as we go through, so that we can take more and more data and put it through the same number of computing machines, and get the results.

There is a tremendous amount of work that needs to be done, because we are trying to handle a volume of instantaneous data here far in excess of what the general practice is.

We want to do some work toward improving our optical network system, in particular this is aimed along one line. We hope to fly in the next several years what is known as a geodetic satellite. That is a satellite that will have a flashing light and that can be tracked by very precise optical methods that will tell us very, very precisely where it is. The optical methods are far more accurate than any of the radio methods we have at the present time.

However, we feel that the present optical systems that we use, Baker Nunn cameras and this sort of thing, are not as precise and not as accurate as we would desire them to be to get the utmost accuracy from this geodetic satellite. And hence we propose to do reseach and development in the improvement of the optical systems.

Now, we have an item through here in the advanced technical development that is about consistent over a 3-year period, around $500,000 a year, called the research and development in Mercury tracking net techniques.

This is actually a contract with the Lincoln Laboratories of Massachusetts Institute of Technology, more or less as technical consultants to us, on setting up and refining this Mercury tracking network, not only for the immediate problem of tracking Mercury, but to improve the system so that for future man flight we will have an optimum tracking system since it is such a vital part, the safety of the man is at stake, it is a vital part of any kind of a flight operation.

Then, we are concerned with improving our deep-space tracking dishes, not just the dishes themselves, but the whole deep-space tracking stations.

As we visualize flights far beyond the Moon, out to the nearby planets, and as we visualize flights to the Moon that will require a considerable amount of ground command from the Earth to the vehicle to perform a certain maneuver at a certain time, it is obvious to us that the present deep-space equipment is not of sufficient accuracy, or state of development, I should say, and hence we propose to do research and development in trying to improve what we call the gain of the antennas.

The gain is the amount of amplification of the signal.

I believe it was cited in testimony before you that the transmitter power of the Pioneer probe that went by the Moon was of the order of two-tenths of a watt transmitted power, about what you get from a two-cell flashlight.

It is necessary to take this very weak signal, which of course is dispersing in all directions, to collect it with these very large dishes, and then to amplify it as much as possible to make it intelligible.

Hence we get into problems where just the temperature of the senser elements alone introduces static, or distortion into the signal.

And so some of our work is directed at going in improved directions toward receiver elements that are maintained at liquid helium temperature, minus several hundred degrees Fahrenheit, in order to cut down the noise level generated within the equipment itself, so that we can take this very faint signal and track it even farther, and track it even more accurately.

These sorts of things are represented.

Altogether, although the present state of the tracking station art is at a point where, as I mentioned earlier, we can consider our tracking stations to be useful day by day tools, we do appreciate, we do realize very keenly that as we try to perform more difficult missions in the future, it is going to be necessary to have even more precise tracking equipment. And the sum of $7,220,000 that we request under advanced technical development item is for the research and developments on these components and subsystems that will lead, we hope, to this improved capability in the future.

Thank you.

Mr. SISK. All right.

Thank you, Mr. Wyatt. You did a very good job of explaining a rather complex number of problems.

On your present program, you are operating with $16,266,000 in this particular portion. Is all of that money going to be used? Is all of it committed? Are you going to have any carryover?

I realize it may be a little difficult to break down these programs by items, but I was a little bit curious as to what extent——

Mr. WYATT. Sir, I don't recall the number precisely, but as I recall our latest programing plans, the carryover, if any, is going to be measured in hundreds of thousands of dollars, low hundreds of thousands of dollars, that we will not actually have programed and committed by the end of this fiscal year.

A good many of these charges are rather firmly known, because they are negotiated contract charges for the operation of these stations in all. Others are of course estimates in the research and development field.

But we are far enough along this fiscal year now, I feel I can say safely there is going to be very little of this money that we will be able to carry over into 1961.

Mr. SISK. And you have firmly enough committed already so far as contracts and other material and equipment and so on that falls in this category, that you very definitely will need the amount, the 32 million-plus, which is double what you had this year, for the coming year?

Mr. WYATT. We believe that this is a tight figure that we cannot operate with any reduction in it.

Mr. SISK. Does the gentleman from Indiana have any questions?

Mr. ROUSH. I have no questions, Mr. Chairman.

Mr. MCDONOUGH. No questions.

Mr. RIEHLMAN. Not a thing, Mr. Chairman.

Mr. SISK. Mr. Morris?

Mr. MORRIS. No, Mr. Chairman.

Mr. SISK. It looks like you did a pretty good selling job on this.

Mr. Hines.

Mr. HINES. I don't believe I heard you list other countries that will be cooperating with NASA on tracking, outside of Jodrell Bank and Fort Churchill. Can you tell us what other countries will be in this program? Will Japan, for instance, assist NASA in tracking?

Mr. WYATT. We will have stations in Japan.

Australia, in particular, has been most cooperative.

We have several stations, actually, a minitrack, a Mercury, and a deep-space station, all in their Woomera complex. They have been most cooperative and assumed a large fraction of the operating costs of much of that equipment.

Mr. HINES. Will they be using some of their own equipment?

Mr. WYATT. Yes, they are using their own equipment. By and large, all of our stations are operated using local personnel. We generally have—for example, in the minitrack stations, we have a NASA station manager.

We try wherever possible, however, to use the local people. For example, in some of our South American stations, the contracts are actually with the University of Chile, for example, and the University of Chile provides the operating personnel, except for the station manager. We do this wherever possible.

Mr. HINES. Are your negotiations with these countries through the State Department, or is it done directly between NASA and the countries concerned?

Mr. HORNER. The original negotiations and contacts are made through the State Department. We directly, then, deal with some technical entity in the foreign country.

We have established relationships now with substantially all of the countries we intend to do business with in the next couple of years.

Mr. HINES. I see.

Is there anything to prevent you from making a contract directly with private organizations within any of those nations?

Mr. HORNER. No. As a matter of fact, we have many such contracts and we have others under negotiation.

Mr. HINES. Thank you.

That is all.

Mr. SISK. Mr. Wilcove.

Mr. WILCOVE. Looking forward to the future, after fiscal year 1961, do you estimate any additional funds will be needed for further completing the tracking and data acquisition network?

Mr. WYATT. For completing the construction and equipment fund?

Mr. WILCOVE. For additional network.

Mr. HORNER. We will have a continuous requirement for funds to bring into operation the anticipated improvements which will come out of our technical development program.

We certainly have a requirement to improve, for example, the deep space net.

We will have to provide improved components, improved elements, into those stations if we are going to accomplish the missions that we have planned.

Mr. WYATT. I might point out as a typical example, Mr. Wilcove, one of the research and development areas we are looking into is that of running the frequency of the Minitrack stations up to around 2,000 cycles, where we are now at either 108 or 136. We are going to the 136 figure.

Now, if we can go to 2,000-cycle operation with those stations, it will permit us what is known as a much broader band width by which we can transmit data.

The band width is significant in this sense, that in telegraphy, for example, it does not take much frequency spectrum to send a telegraph signal, because it is a very simple signal and you don5t have to have very many cycles of radio spectrum in order to get the data across.

A telephone, or telephonic wireless communication requires a somewhat broader band width because you have to have enough frequency spectrum to translate the modulations of the voice. There are tonal qualities, and inflections, that require that you use a broader chunk of the radio spectrum in order to get them across intelligibly.

If you come to something like television, it requires perhaps 1,000 times as much band width as a telephonic link in order to get the very complex television picture across.

When we operate at the frequencies in the minitrack system that we are now, that is down in the hundreds of megacycles, we actually are restricted to operating with very few kilocycles, or a thousand cycles of band width, and this means that we can only transmit fairly simple signals back.

We spoke of the kinds of signals, whether they are dot-dash, or whether they are frequency variations, we are constrained to operate with very narrow band widths.

Now, if in the future we want to transmit data such as television pictures, and this sort, we will have to go to a broad-band width, and hence, because of the crowding of the radio spectrum, we think that around 2,000 cycles a second would be an attractive place to go. We could get lots of band width.

So we will be doing research and development on trying to work out the problems of using the minitrack at 2,000 cycles. If this works out, then several years in the future we will probably be requesting construction and equipment money in order to modify the minitrack stations to permit them to operate as operational stations at this higher frequency. So this sort of thing will go on from time to time.

Mr. MCDONOUGH. You don't have to go through the FCC for these frequencies, do you?

Mr. WYATT. We don't go through FCC, but we do have to get an allocation of frequencies made to us. We can't just go in and say we are going to operate on this frequency. It is a frequency assigned internationally.

Mr. MCDONOUGH. I see.

On your Mercury tracking net technique here, does that provide for transmission of communication by voice?

Mr. WYATT. Yes, sir. We have voice communication. We have telemetry communication of the sort we have been talking about from the satellites. Those are the two principal areas. It is telemetry channels and then the voice channels.

Mr. MCDONOUGH. What about television?

Mr. WYATT. No, sir. There is no provision at the present time for anything of the magnitude of band width of the television sort.

Mr. MCDONOUGH. Mercury will be at what distance away from the Earth in its orbit?

Mr. WYATT. The farthest vertical distance will be around 120 miles or so. However, lateral or straight-line distances might be perhaps 500 miles, from a given receiving station.

Mr. MCDONOUGH. You have no problem of communication at that distance?

Mr. WYATT. Well, we have a very real problem, in that we have to space our stations fairly close together so we don't lose the vehicle for extended periods of time between stations. Because again the transmission will be primarily on a line of sight.

We do have a back-up voice transmission system that is in the short wave, and theoretically we can talk from any one station around the world to the capsule.

However, our principal system is a line of sight frequency system, the one that we rely on, and the one we have to rely on for the data transmission of the telemetry data.

Mr. MCDONOUGH. In the shots with the Mercury capsule that you put the monkey in——

Mr. WYATT. Yes, sir.

Mr. MCDONOUGH. And which you recovered, did you get any sound effect from inside the capsule from the monkey? Did he make any noise that you could hear?

Mr. WYATT. No, sir. We did not have a transmitter in that particular experiment for that particular quantity.

We have made noise measurements not in vehicles with monkeys, but we have made noise measurements.

Mr. MCDONOUGH. I see.

Mr. WYATT. Inside.

Mr. WILCOVE. With the exception of funds you might need for improvements, are the funds you are requesting for 1961 sufficient to meet your program needs?

Mr. HORNER. Mr. Wilcove, the funds that are in this particular account are for the operation of the stations, and this will be a repetitive annual requirement.

It is likely that it will increase a little bit over fiscal year 1961 because we have not quite reached the level of operation which we anticipated in our 10-year plan that we showed the committee earlier.

As far as the construction and equipment account is concerned, the bulk of our requirement is in the fiscal year 1961.

There will be, I think we can anticipate, occasional additional requirements in new construction, but we will have established, we will have largely established the framework of our total space communication system.

Mr. WILCOVE. The annual sum for operation will run each year somewhat above the amount you have allocated?

Mr. WYATT. I think it will go somewhat higher than $32½ million as time goes on. We will have more flights. This means we will have to have more equipment.

In some of the areas we have to have more personnel, because the personnel now work either one shift or two shifts, but as we get more and more flights simultaneously we will have to operate some of these stations on an around-the-clock basis. It will be necessary to add third-shift employees and this sort of thing.

Mr. WILCOVE. When you get around to the circumlunar shots, both manned and unmanned, will you have to make any substantial additions?

Mr. WYATT. We will probably have to make equipment additions. We may not have to add dishes, as such. I am not positive whether the construction program calls for a command and receiving dish at every station.

We do have them at Goldstone. Eventually, we may have them at the other two stations, South Africa and Woomera.

When we get to something as specialized as the circumlunar flights, we will probably have to put special command electronics equipment into these dishes that will be tailored for that particular mission.

I cannot speculate in detail as to what this will be, but I would expect a major undertaking as that would have its side effects of requiring some special ground equipment to follow it.

Mr. WILCOVE. You don't anticipate any substantially new techniques will be needed for that?

Mr. HORNER. Well, we certainly need improvement over current techniques, or we need new techniques for that operation.

Mr. WYATT. Yes.

Mr. HORNER. Probably earlier in our program than that, however, there is the possibility of a major influence in the operations of ground stations in any applications of satellites.

Our applications program now in meteorology and communications, for example, is purely an experimental effort. If we are successful in these efforts, and there is a nationally supported requirement for a space base meteorological system, there will have to be a major augmentation of the ground facilities in order to accommodate such a system, whether it is done in our program or the program of the Weather Bureau or the Defense Department. This question hasn't really been resolved yet.

Mr. WILCOVE. Just one more thing.

Can you cite the government, semigovernment, and private agencies involved in the administration of your network and data acquisition program?

Mr. HORNER. In terms of in-house versus contract-type operations?

Mr. WYATT. I am not sure I can answer that wholly, Mr. Wilcove, but let me run down and see if this is what you are seeking.

The Minitrack system is administered by the Goddard Space Flight Center, part of NASA, through a contract with the Bendix Aviation Corp., a private company.

The Deep Space Network is administered by the Jet Propulsion Laboratory, which is under contract to the NASA, as a semi-NASA

direct organization, certainly governmental supported, nonprofit actually. It is operated by the California Institute of Technology, under contract to us. They are administering the whole three station Deep Space Network.

The Optical Station Network is by contract with the Smithsonian Institution. I'm not sure by your definition whether you call it semigovernmental, or nonprofit.

The Mercury Network is a little more complex. It is being operated partly by personnel or will be operated partly by personnel under contract to the NASA, and partly by the Department of Defense, utilizing the Department of Defense wherever possible, and the contractors to the Department of Defense.

I'm not sure whether this is wholly responsive to your question.

Mr. WILCOVE. Pan American World Airways would also be a contractor?

Mr. WYATT. As a contractor to the Atlantic Missile Range, yes, sir.

Mr. WILCOVE. Thank you, very much.

Mr. SISK. All right.

Are there any further questions on the tracking and data acquisition part of the program?

If not, that completes our various programs with the one exception which we skipped over the other day. That has to do with the nuclear systems technology, which we will be taking up Friday morning, at which time we will have AEC people testifying. On Friday afternoon we will conclude with your people.

In going back over this in general, starting on page 168, where we start with the vehicle system technology down through the other three major items, I think that there might be some general questions the members of the committee would like to ask.

I know I have one in mind. So while you people are still before us, we might take just a quick few minutes here and briefly run back in case there are any questions.

The gentleman from California, Mr. McDonough. Do you have any further questions?

Mr. MCDONOUGH. With reference to what?

Mr. SISK. I am referring to the whole bundle now.

Mr. MCDONOUGH. What page are you on?

Mr. SISK. Going back to the beginning, page 168. In other words, starting with vehicle systems technology of $21 million, space propulsion technology, and after that solid rockets and liquid rockets, and the various vehicle programs, such as Scout, Delta, Vega, Centaur, and Saturn.

I thought while we had Mr. Horner and Mr. Wyatt before us this afternoon, that if there are any further general questions you would like to question them further about the program or the moneys involved herein.

If there are not, why then we will dismiss them and proceed into executive session to see to what extent we can formally approve, disapprove or change, as the case may be, the funds in the various subtotals.

Mr. MCDONOUGH. No, I have no questions, Mr. Chairman.

Mr. SISK. The gentleman from Indiana.

Mr. ROUSH. I have no questions.

Mr. SISK. The gentleman from New York.

Mr. RIEHLMAN. I have no questions.

Mr. SISK. The gentleman from New Mexico.

Mr. MORRIS. I have no questions, Mr. Chairman.

Mr. SISK. I have one question I would like to inquire into, and this goes back again to the one we talked around quite a bit. I will not make this long, Mr. Horner. But a couple of days ago—I believe it was a couple of days ago—in a discussion on the F–1 engine, which we went over rather thoroughly, I think, in answer to a question which I asked you with reference to maximum development, you indicated, as I recall, that the amount of money involved here would not represent or permit the maximum development.

Now, the reason I am asking you the question now is this. Are you in a position to recommend, either as an individual or on behalf of NASA, any addition to that $63 million fund which is here devoted to the liquid rockets. Do you get the point of my question?

In other words, if under that portion of the program devoted to the F–1 engine, you feel that the amount of money budgeted here does not permit the maximum development, could you give me a figure wherein you believe a maximum development could operate?

I am speaking actually of the $41 million now, on page 176 of the backup books. It is a part of the overall $63 million under rocket propellants.

I don't mean by this question to put you on the spot in any way. This may be a question you would prefer not to answer now. Perhaps you would like to think it over and submit it to us within the next day or so.

I will tell you frankly why I am interested. I am concerned about this particular program going ahead. I intend to continue my interest and concern in the hopes that the agency, through the other agencies who are in a position to do so, will give this development a DX priority. I'm going to continue to be interested in the push on that thing within the balance of reason, believing very firmly it represents the foundation vehicle, so to speak, that might give us some accomplishment in this so-called race in which we are indulging in at the present time.

Do you have any comment at all that you want to make?

Mr. HORNER. I can make a few brief comments now, Mr. Sisk.

Mr. SISK. I don't mean for you to go back and review the whole matter, but you recall that when we were discussing this I asked a specific question on maximum development, and you said, I think in fairness, you felt possibly this is what you would normally use in the orderly procedures under which you are going. If I'm not mistaken, your answer was this: "The answer to your question then, Mr. Sisk, is, 'No, it is not enough.' "

That was in answer to a question in which I had said, "Well, of course, that is the thing that gets on my nerves a little bit, this hedging around on the terms when I think we should be moving ahead at the maximum rate of development. This is not a criticism of your terminology because I realize you are under the gun."

And then your answer was: "The answer to your question then, Mr. Sisk, is, 'No, it is not enough.' "

Mr. HORNER. Yes, sir; I recall that.

I think I can best put this in context by saying that I would give the same answer to a similar question concerning every other element of our program.

Mr. SISK. Sure.

Mr. HORNER. I don't, offhand, think of any element of our program that couldn't use more resources iin accelerating the development cycle.

It is our objective, in managing the program, to use the resources that are provided to us in producing the best balanced and the most efficient program we can.

In the context of the program that we have presented with our authorization request, I would not recommend any further increase of the F–1 engine support, because I think it would produce an imbalance.

Now, you must recognize this is a judgment in an area of extremely difficult judgments. And I couldn't say an additional million dollars, or a million dollars less, is any worse or any better for this particular balance. But we think that this is reasonably close, and that it is certainly our judgment it is the proper balance of rate of development for the F–1 engine in the context of our overall program.

I think I mentioned at that time that there is some danger that we can become overfascinated with the requirements of propulsion, simply because this is the thing that has been brought to our attention by international situations at the moment.

I think it would be terribly wrong for us to concentrate solely on development of propulsion devices and have no realistic way to use them when they are available in operational form.

As regards the question of priority, I think I explained the priority system and stated earlier that a DX priority appended to this particular development would not in any way help it as far as carrying on the development.

Mr. SISK. The gentleman from Indiana, I believe, was seeking recognition.

Mr. ROUSH. Perhaps this has been answered now, but if this engine was assigned a DX priority, would it require more funds than the $41 million? And if so, how much more would be required?

Mr. HORNER. The assignment of the DX priority has no direct relationship to the level of financial support.

Mr. ROUSH. DX priority, as I understand it, relates to the matter of procuring materials. It has nothing to do with such things as overtime, additional effort, and what have you. Is that correct, Mr. Horner?

Mr. HORNER. I don't know as it is accurate to say, Mr. Roush, it has nothing to do with these things.

There are indirect relationships in that if you have a roadblock because of the unavailability of certain key materials, then this obviously does affect whether or not you use overtime on the project.

It has that sort of secondary relationship. But we have not had these kinds of problems with the F–1 engine, and we are advised these kinds of problems are not likely to occur.

Mr. WYATT. If I may, Mr. Roush, on this point: The DX priority in application is used when you need material and the vendor says,

"Well, you've got to get on the end of the line—I've got a long list of customers."

You just show him the DX priority and say: "I will take the next one that comes off."

It does not, without funds, permit you to say: "Well, put on more people."

If you can pay for people, you can sometimes get it with or without a DX priority. If widgits are in short supply and you say you want a widgit, he says he is making that widgit for another man, but if you have a DX, the other man has to get back in line again.

It does not have any direct influence beyond the dollars, and in many cases if you have the dollars you don't need the priority. In other words, you can tell the contractor to put on another 200 men, and I don't know that the DX priority helps him hire those men. It has no premium in the labor market.

Mr. HORNER. It has also been useful in practice in interrelated work within Government laboratories. In other words, Government laboratories recognize by practice a DX priority in giving relative position to work in their laboratories.

So in those projects where there are a number of different Government laboratories at work on the project, such as this Project Mercury, for example, a DX priority is useful even if there aren't any direct material shortages.

This is not true in the case of the F–1 engine. This is all under the work of one contractor.

Mr. ROUSH. I wasn't here in the discussion before, and because I wasn't, I am not going to pursue this any further.

Mr. SISK. I appreciate the fact that we did go into that rather extensively, and you might check the record on that.

I have been interested in this F–1 program and I don't altogether agree, and I don't necessarily disagree, with the statement by the gentleman, but I am concerned about a top priority on this F–1 engine.

Regardless of this explanation of material being involved in the so-called DX priority, whether it be a DX or whatever it is, I want to see the highest possible use made of moneys available to you for its development.

In other words, I'm concerned about its priority, so far as its call on the dollar, plus its call on the technical know-how, and the knowledge and the abilities and the scientific information is involved.

It is all one ball of wax. If it isn't DX, it is VPX, or something else. I don't care what it is called.

You know what I'm concerned with, which is giving the F–1 engine top priority, which I don't think it has at the present time. What I'm concerned with is what seems to me to be a little bit of complacency on this particular thing, but we won't go back over that again now.

Mr. MCDONOUGH. I am just trying to summarize your thoughts and the thoughts of Mr. Horner here.

It seems to me he is informing us he is asking for a specific sum of money here which he can physically, economically and practically spend on this project during this fiscal year.

But it seems to me that there is also authority in the original act that permits the Administrator to shift funds to some other project

if he needs to, so that the $41 million is not a static sum of money. If he should find a breakthrough where he could speed up the work faster and use the money for some other project and take it away, hold back on one, and improve on the other, the money is there.

Mr. HORNER. Well, within the total authorization that is available to us, we recognize that authority, and we have used it already in the program of transferring funds between different research and development projects to better fit our needs during the operating year.

However, we were not so constrained in forming this budget authorization. This amount of money represents our assessed judgment of the level of support on the F–1 engine, which would produce it in balance with the rest of our program.

Mr. MCDONOUGH. Yes.

Mr. HORNER. What I'm literally saying is, I would not recommend a higher level of support on the F–1 engine without a magnification of the whole space program.

Mr. MCDONOUGH. Oh, I see. It is part of the system, and it has its place in the system in relationship to all the other projects?

Mr. HORNER. That is exactly right, yes, sir.

Mr. MCDONOUGH. I don't think there is anything holding you back.

Mr. SISK. I might ask you, did you or a representative who is now present hear Dr. Pickering this morning when he testified before the full committee?

Mr. GLEASON. We had somebody there.

Mr. SISK. He made some rather significant statements on this. I do not say he disagrees and I am not trying to create a controversy as that is not what we want. We want to proceed ahead and not create a controversy, but certainly he made significant statements, one or two in answer to my colleague, Mr. Roush, to the effect we could do things right now if we had the additional thrust. We have the equivalent to put on there, we have the payload, but we need the thrust. This is contrary to the impression you are giving now, Mr. Horner, that we have no additional need for thrust.

I do not want to leave the impression we could not make use of the larger vehicle if we had it. If I understood Dr. Pickering at all this morning, and if I understood Dr. Von Braun, and others, we desperately need more thrust.

Maybe we do not need a million and a half pounds, but I do not think you want to leave the impression that we could not quickly make use of some additional thrust over what we have available now.

Mr. HORNER. No, sir. I certainly do not. We are spending almost half of our budget in that objective.

Mr. SISK. That is the point I wanted to make. I did not want to leave the impression, or have the impression left, that it was going to be 1970 before we were going to have need of this and that, as we moved along here, it would come along only at a time when we needed additional large-size boosters. This, of course, is part of the real cornerstone and concern in the end.

Mr. HORNER. In the final analysis, Mr. Sisk, it boils down to the question of how many different developments we work on, at what rate simultaneously to produce this additional thrust that we need. We have many that we are now working on.

The F–1 engine is one of those.

What I am saying is that the F–1 engine is being properly supported in this budget authorization in balance with all of the other things we are doing in this area, also.

Mr. SISK. Well, it is my understanding from what Dr. Pickering said this morning, and this same thing I think had been stated before, that, of course, the ability of the Russians to hit the moon was based on the fact that they had in there a substantial amount of guidance. It takes weight to put that type of equipment aboard, and therefore, they were able to hit the moon.

Now, after all, if we have—and I have never admitted and I do not think you people have admitted that—basically as good guidance equipment generally as Russia has, if you follow that to its logical conclusion, then, if we had sufficient thrust to put in guidance what we had available and the equipment, we could hit the Moon, too. Yet we have not been able to do it.

This is just talking a practical layman's language, because, after all, that is all I am. Dr. Pickering made this statement this morning that we did not have the thrust to put aloft the equipment that we needed to really do the accurate job of pinpointing the Moon.

This is why I wanted to make it clear that if I understand the statement by these various people, we, in my opinion, desperately need additional thrust, and we need it as quickly as we can get it.

Mr. HORNER. Yes, sir. I would need to point out hopefully within the next 12 to 14 months, we will fire a vehicle which will produce the same load-lifting capability, an equal load-lifting capability that the Russians have demonstrated thus far. This is the Atlas-Agena.

A little more than a year later, we will have another vehicle in the early stages of firing, the Atlas-Centaur, which will be two to three times larger in its load-lifting capability.

Two years later we will have the first—2 to 3 years later, we will have the first Saturn load-lifting capability, which is on the order of eight times that large.

I just mention these things as illustrating the fact that they are working on a systematic approach improving our weight-lifting capability, and in the context of bringing along at the same time, not only our load-lifting capability, but our ability to use that load-lifting capability, we feel we now have the proper balance in the program.

Mr. SISK. Any further questions?

Mr. MORRIS. No, sir.

Mr. SISK. Mr. Wilcove?

Mr. WILCOVE. Mr. Horner, I am disturbed, as the chairman is, over your statement of several days ago, that the funds requested for the 1961 fiscal year will not permit the maximum level of development for the F–1 engine. I want to ask you this question: Will you say now that for 1961 you do not need additional funds which can be used advantageously for the development of the F–1 engine?

Is that question clear?

Mr. HORNER. Mr. Wilcove, I have been in this kind of research and development program for 15 years, and I have never been associated with a program that had all of the funds available to it that could be used. I think it would be very wrong for us to provide

the maximum funds that could be used for the F–1 engine in its development at the expense of the rest of our program.

Mr. WILCOVE. I will put it another way, then. You are not asking this committee at this time to vote additional funds other than those already requested for the F–1 engine?

Mr. HORNER. No, sir.

Mr. WILCOVE. Thank you.

Mr. SISK. All right, gentlemen. Unless you have some further comment to make, then, I think we will go into executive session.

I want to say this, Mr. Horner. I realize we have been a bit persistent at times, but I think you, and Mr. Wyatt, and the other gentlemen who were here previously were very fine witnesses. We appreciate your sincerity and the good job you have done.

Certainly there has been no implied criticism. As you know, we are all concerned with this and we are all trying to attain the same objective. We sincerely appreciate it.

I believe Dr. Dryden is coming up on Friday.

Mr. MCDONOUGH. I just want to reiterate the chairman's statement. I think you have given us some very intelligent and capable answers to some rather complex questions, to a bunch of laymen who know very little about this business.

I feel confident that we have an organization there that is devoted to doing the utmost to accomplish the objectives we desire in the exploration of outer space.

Mr. HORNER. Thank you. We very much appreciate the interest of this entire committee in our space program.

Mr. SISK. Thank you, gentlemen.

(Whereupon at 3:56 p.m. the subcommittee went into executive session.)

(The executive session will not appear in this volume.)

1961 NASA AUTHORIZATION

FRIDAY, FEBRUARY 26, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE No. 4,
Washington, D.C.

The subcommittee met at 10 a.m., Hon. B. F. Sisk (chairman of the subcommittee) presiding.

Mr. SISK. The committee will come to order.

We are very happy this morning to have with us Brig. Gen. Irving L. Branch, U.S. Air Force, Aircraft Nuclear Propulsion. Also Col. Jack L. Armstrong. I believe General Branch, we have before us a prepared statement from you.

General BRANCH. Yes, sir.

Mr. SISK. Do you expect to read that statement this morning?

General BRANCH. If you would like to have me do so, Mr. Chairman.

Mr. SISK. Colonel Armstrong, will you have a statement of your own?

Colonel ARMSTRONG. No, sir.

Mr. SISK. Are you more or less just here to back up General Branch?

Colonel ARMSTRONG. I am assisting.

Mr. SISK. All right.

General Branch, you may proceed to give us your statement. We would be glad to hear it.

STATEMENT OF BRIG. GEN. IRVING L. BRANCH, USAF, CHIEF, AIRCRAFT NUCLEAR PROPULSION, ASSISTANT DIRECTOR FOR AIRCRAFT REACTORS, ATOMIC ENERGY COMMISSION; ACCOMPANIED BY COL. JACK L. ARMSTRONG, USAF, DEPUTY CHIEF, AIRCRAFT NUCLEAR PROPULSION, AND LT. COL. GUVEREN M. ANDERSON, PROJECT OFFICER FOR SNAP, ATOMIC ENERGY COMMISSION

General BRANCH. Mr. Chairman and members of the House Committee on Science and Astronautics, it is an honor and a pleasure to be invited to appear before this committee to discuss the national nuclear aerospace programs.

As Assistant Director for Aircraft Reactors of the Atomic Energy Commission, I am charged with the responsibility for four aerospace nuclear development programs in the fields of propulsion and auxiliary power. These programs are the manned nuclear airplane project, both the direct and the indirect cycle engine systems; the nuclear ramjet program known as project Pluto, which is to provide the pro-

pulsion system for the Slam weapon system; Project Rover, the nuclear rocket program; and Project Snap, the systems for unclear auxiliary power program. I understand that this committee has had a briefing on Slam. I further understand from your invitation that your major interest, at this time, is in our space oriented program, so I will touch only briefly on our manned nuclear airplane and the Pluto/Slam program.

The nuclear aircraft program is a joint Air Force-AEC effort to apply nuclear energy for the propulsion of manned aircraft. And I might add, this is a national program.

This program encompasses two major efforts. First, in the direct cycle system, air passing directly through the reactor is heated and expelled through the turbine and jet nozzle to provide thrust in somewhat the same fashion as a chemically powered turbojet engine. The direct cycle program is being carried out by the General Electric Co. at Evendale, Ohio.

The other manned aircraft nuclear propulsion effort is the indirect cycle program being carried out by the Pratt & Whitney Aircraft Co. of the CANEL facility in Middleton, Conn. In this case liquid metal is used to conduct the heat from the reactor through a radiator heat transfer system to the engine turbine and jet nozzle. In both cases, the reactor replaces the conventional chemical fuel and combustion to produce the required energy.

In support of both of these programs, reactor experimental work is underway at the National Reactor Test Station at Arco, Idaho. The major problems we are solving in applying nuclear energy to aircraft propulsion include developing reactor configurations with sufficient power densities and providing reactor material capable of withstanding the very high temperatures that are required to produce the necessary engine thrust.

I am happy to report that we have made encouraging progress in the manned aircraft propulsion work during the past year. We have achieved results with reactor materials and component experimentation which gives us great confidence in proceeding toward high performance manned aircraft systems in the not-too-distant future.

Somewhat akin to the manned aircraft engine effort, in that the reactor is a direct cycle air-breathing system, is Project Pluto. This project is aimed at proving feasibility of using a nuclear ramjet for missile propulsion. Project Pluto is being accomplished by Lawrence Radiation Laboratory in California with the Air Force funding engine design and development assistance through the Marquardt Corp. The missile application of the nuclear ramjet project is known as Slam, short for supersonic low altitude missile. Three airframe companies have made studies of the Slam system.

We intend to conduct the first Pluto reactor experiment this year. This experiment will confirm our theoretical work and should permit rapid advances in the application of nuclear ramjet technology to Slam missile systems.

Now to discuss our space-oriented programs. These are: First, nuclear propulsion for rockets, a project known as Rover, and second, a program to produce electric power from nuclear sources for satellite and other space applications, a project known as SNAP (systems for nuclear auxiliary power).

Project Snap is a many faceted program, primarily directed at producing large quantities of electrical energy for space applications in small long-lived packages. There have been two major approaches in this program—one, the use of radioisotopes as heat sources, the other, the use of very small compact reactors.

You may recall that slightly more than a year ago Snap III, a radioisotope device, was shown to the President and was announced to the public. This device, powered by an isotope of polonium was designed to provide 5 watts of power for extended periods. This particular model which we have here today was fueled last year and has gone through almost four half-lives and still has enough power to drive this small motor. It is producing enough power to drive many electrical devices used in space vehicles. The Martin Co., Baltimore, Md., has been our major contractor in devising the methods of extracting electrical energy through the use of radioisotopes as heat sources.

We also have here a full scale model of a Snap II reactor for providing energy that can be converted into 3000 watts of electrical power for periods of at least a year.

Our major contract in the Snap reactor field has been Atomics International of North American Aviation in California. Thompson Ramo-Wooldridge is a subcontractor to AI in the development of nonnuclear electrical generating systems of the program.

Out of our efforts to produce electric power for space application, like Topsy, a whole family of Snap devices has grown for many applications both on and off the earth's surface, including electrical sources for such applications as ion propulsion, which appears to be a feasible propulsion route in the next generation of space vehicles.

One of our major areas of interest, naturally, is in finding lightweight methods of converting nuclear-generated heat into electricity. You may recall that just about a year ago, Los Alamos announced a radical new departure in the direct conversion of electricity from a nuclear source. This device is known as the plasma thermocouple. This is a direct side benefit from the Rover program which may lend itself to the production of electric power for a variety of different applications.

Project Rover, our nuclear rocket development, is being conducted as a joint AEC–NASA program in which the AEC is responsible for the overall ground feasibility demonstration phases with NASA supporting this effort. Los Alamos Scientific Laboratory conducts the AEC portion of the program. NASA is, of course, responsible for follow-on flight application phases of the nuclear rocket development and its eventual application to the national space program.

You will recall that the Kiwi–A experiment, completed last July–at Jackass Flats in the Nevada test site, proved not only the feasibility of the Rover device, but, also, was successful beyond our original expectations. We expect to be able to test next summer a vastly improved fuel element which will be an early step toward important space vehicle applications.

This is a brief résumé of our four programs associated with aerospace applications of nuclear energy. Colonel Armstrong, my deputy, described to the committee in executive session, a year or so ago,

many of the technical details of these programs. Colonel Armstrong is here with me today and we are prepared to brief you, either at this time, or in more complete detail in your executive session, should you so desire. We both stand ready to attempt to answer any questions you may wish to ask at this time.

I would like further to add that Lt. Col. Guveren Anderson on my right who is the officer responsible for monitoring the SNAP program, is also here to give detailed information on the SNAP program, itself.

Mr. SISK. Fine, General Branch. We appreciate very much your statement here this morning.

Now, I am sure that in the minds of the members of the committee, there are probably a number of questions concerning the interest we have, of course, in nuclear power as applied to this space field. I am happy that you did devote your statement primarily to the space program, the exploration of outer space, and what could be done with that type of vehicle through the use of nuclear power. That, of course, is basically the only jurisdiction this subcommittee has in that particular field.

This subcommittee has been primarily concerned, in the examination of the budget and in the review of the NASA program, with the fact that NASA's overall long-range program, or its 10-year program, which has been presented to us, shows little or no indication of the use of nuclear propulsion in that program.

Of course, that is of some concern to us, then, to know just what is happening, and what is actually being done in this field and whether or not any progress is being made. That primarily has been the reason we were anxious to have you people before us. Before we finally approve our portion of the budget devoted to some possible research in the field, we wanted to have your comments.

Now, the fact is that in this 10-year program which has been proposed to us, NASA representatives stated that nuclear propulsion could not be available for such purposes in this decade. In other words, I would like to have your comments on that, General Branch. Tell us just what is the situation at it exists at the present time.

General BRANCH. No, sir, nuclear propulsion is available within that decade, within the next 10 years, within the next 5 years as a matter of fact. Colonel Armstrong can give specific details about when exactly it can be available if you would like to have him at a later time in a classified briefing, but I would like to point out that we are working very closely with the NASA people.

The NASA people, themselves, are better qualified than I, to explain what their programs require that match with our capability in the Rover development program, but in working very closely with them, we know they have a plan for using Rover in some of their space devices.

As I say, I am not qualified to give specific information on this particular point.

However, we feel that we can develop a Rover device and demonstrate its actual use probably in a shorter time period and quicker time than the requirements stated to us so far have indicated a need for.

Mr. SISK. Well, now, in the budget for 1961, NASA has requested $10 million in the field of nuclear systems technology.

I believe NASA has programed here a test of the Rover reactor. Have you seen this, a copy of their recommendations?

General BRANCH. Yes, sir.

Mr. SISK. On Project Rover and so forth?

I believe $4,300,000 has been scheduled for reactor test support on Rover.

Now, that is up a little, about a million dollars over last year. Then, in applied research on nuclear rockets, NASA is asking for a million dollars, and for breadboard engine design, a couple hundred thousand.

Wait a minute, that is the portion having to do with nuclear heat transfer.

I would like to ask for your comments generally on that, General Branch. Certainly there is no intent here to create controversy between the people you represent and NASA. But in view of our great interest in the F–1 engine and in the Saturn project, and considering what we are going to do with reference to funding those programs, we are vitally concerned with what effect possible nuclear propulsion could have on these projects.

Would you make any comment as to whether or not you feel that this is a sufficient amount of money, too much money, too little money, to support properly this particular field? I am speaking now of the three figures which I mentioned which total up to $51\frac{1}{2}$ million.

General BRANCH. It is our opinion that this is a sufficient amount of money at this particular time to match-up our capability with their requirement, and also to match-up our capability with as rapid a growth in the state of the art at this particular time as we can go. We feel in the future we can go faster than requirements call for, but at this particular time, this is a sufficient amount of money to make a compatible requirement with our development capability.

Mr. SISK. All right.

On the SNAP–8 development, NASA is asking for $2 million. What about that?

General BRANCH. If I may, I would like to defer that question to Colonel Armstrong; he is more familiar with the specifics.

Mr. SISK. All right, colonel.

Colonel ARMSTRONG. I think both questions relate to the divided responsibility in the program wherein we in the Atomic Energy Commission are involved in the reactor responsibility, and the NASA is involved in the responsibility for those associated nonnuclear components that go to make a complete system of it.

In the case of SNAP–8, the money which they have in for this year is for the rotating equipment to generate the electricity from the heat which our reactor will produce.

I think this is sufficient money for the rotating machinery, because the reactor is in its very early phases now, although the reactor itself, is a direct offshoot of the SNAP–2 reactor which is quite well proven at this point.

I feel that the $2 million is adequate.

Mr. SISK. Now, in addition to that, on the nuclear electric power generating systems, NASA is requesting, under applied research on high-power systems, $2½ million. Do you have any comment on that, Colonel Armstrong?

There again, we have not been briefed as yet by NASA on exactly what might be involved. I am assuming this has to do with some rather basic research in rather long-range programs.

Colonel ARMSTRONG. I am sorry, I can't relate high-powered systems as to whether this is toward a higher powered SNAP system or a higher powered Rover system. Do you have the information on that, Andy?

Colonel ANDERSON. This is aimed at the requirement NASA has placed on the AEC to investigate space powerplants in the range of a 10th or 1 megawatt, and along with this investigation, one must look at working fluids which operate at much higher temperatures. The work that NASA is doing in this regard, I am sure is in this field of endeavor, to investigate the working fluids that would be necessary to operate such systems.

Mr. SISK. Does the gentleman from Indiana have any questions?

Mr. ROUSH. I wanted to ask if these are the sums you asked for when you drew your own budgetary requirements?

Colonel ARMSTRONG. Well, these sums here are sums which NASA has asked for, and they are sums which were coordinated with the work that we were jointly doing.

The Atomic Energy Commission budget, of course, is separate from this, and all of the funds for the Rover reactor and the SNAP reactors is contained in the AEC budget.

Mr. ROUSH. Well, surely you must have submitted some of your requirements to NASA people before they could have asked for these figures, Colonel. I am asking if you submitted the same figure as we see here in this budget breakdown?

Colonel ARMSTRONG. It isn't quite this cleancut. There is what is known as a Rover Coordinating Committee, and a SNAP Coordinating Committee between the interested agencies who meet quite often on the interrelated responsibilities and what is needed to bring these programs to a compatible end.

At that time we discuss such things as our development schedule and the requirements which each of us feel the other agency must come forth with. We do not in any way say the amount of funds we think you ought to have to do your job is so much.

We tell them what we think their job is, and they tell us what they think our job is. But the funds which go on that come from our independent analysis of what the problem is.

So I can't say that we have turned to NASA and said, you don't need 4, you need 4.2, or anything of the kind.

Mr. SISK. General Branch, do you have some charts to present to the committee in open session here?

General BRANCH. Yes, in case you wanted it, I had prepared some slides here that show the overall aircraft nuclear propulsion program, including manned aircraft into space. We can skip the manned aircraft part of it or we can go over it quickly. I thought you might be interested in it because it has a bearing on the space program and nuclear development.

Mr. SISK. How long will that take, General Branch?

General BRANCH. Five or ten minutes, whatever you like.

Mr. SISK. We will take a look at those before we continue the questioning. My attention was called to the fact you had these by Mr. Wilcove. I wasn't aware of these slides.

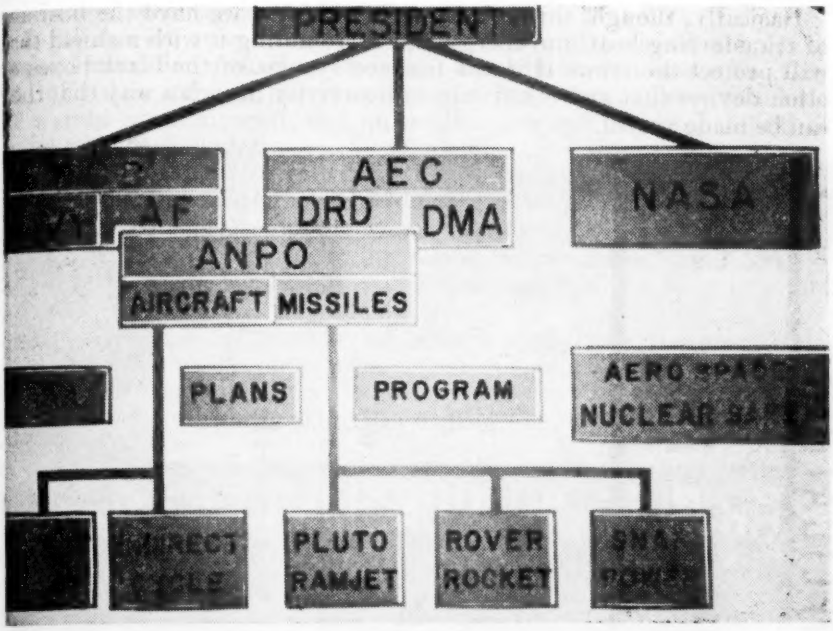

FIGURE 13

General BRANCH. This first chart shows the organization of our aircraft nuclear propulsion program. As you can see, the ANPO, the Aircraft Nuclear Propulsion Office which is a part of the Depart- of Defense, is divided up into aircraft and missiles. It is the space end of the thing we will be addressing ourselves to today (fig. 13).

My responsibility is directly to the Director of Nuclear Development. Dr. Pittman is responsible for that. I am a part of the AEC staff.

I also have a responsibility directly to the Department of Defense in that I am directly as an assistant to Lt. Gen. Roscoe S. Wilson, who is the deputy chief of staff-development, and I am his assistant as assistant deputy chief of staff for development of nuclear systems.

So within the Air Force staff, I am responsible for all nuclear systems applications.

We have as you can see on this chart here, a variety of different breakdowns here. The aircraft divides up basically into the direct and indirect cycle system, and then the missile program, as you can see, divides into Pluto, Rover, and SNAP. It is Rover and SNAP that is the part that is most important to space.

Under the principles of nuclear power, as you know, we use heat sources primarily for the space business, and we will get into that in some detail later on if you like, into reactors and radioisotopes. In the

SNAP series you see we have them numbered serially, the odds and even numbers which we will explain a little later.

In the reactors, however, we derive our power for the propulsion of aircraft primarily, and the development techniques, the things that we learn in working in the development of aircraft apply directly to techniques that can be applied to space, in space applications.

Basically, though, through Einstein's theory, we have the business of transferring heat into energy and surrounding it with a shield that will protect the crews if it is a manned system, of the black boxes or other devices that are sensitive to radioactivity in such a way that they can be made useful.

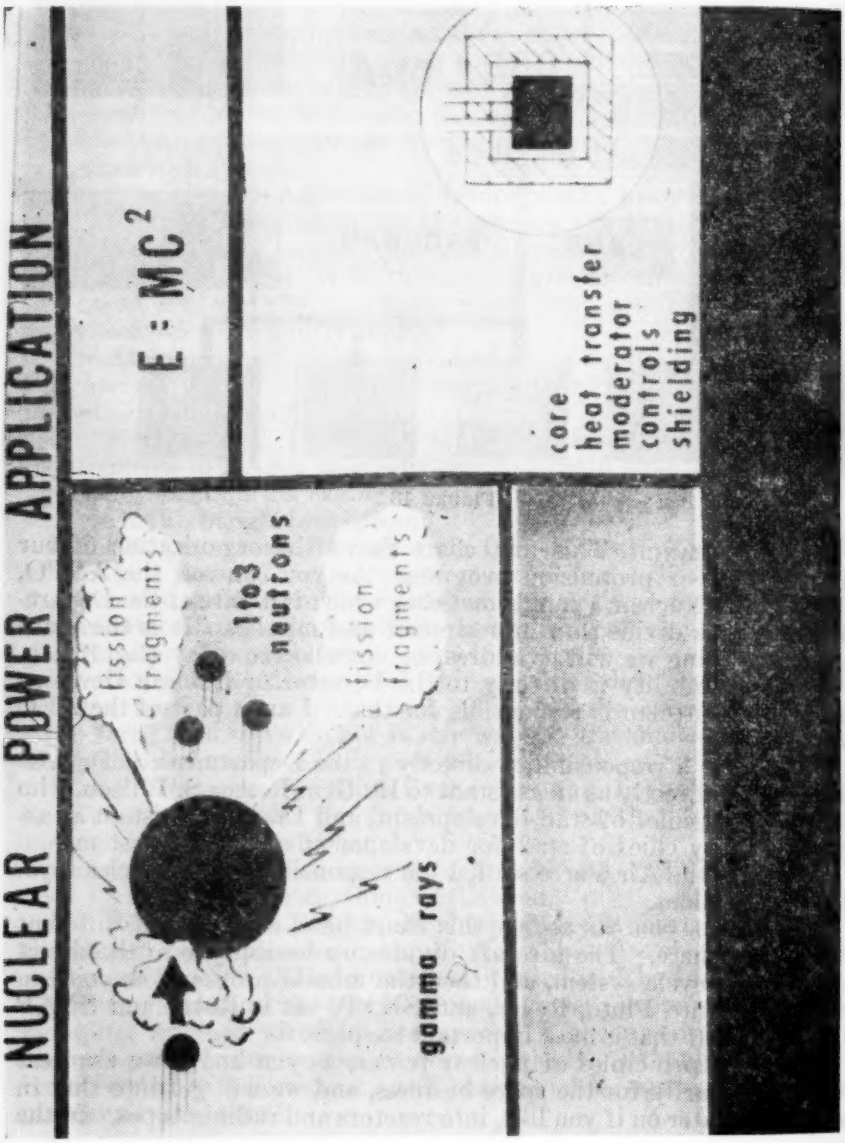

FIGURE 14

At the bottom of this particular chart there is something that may be of interest to show the problem that we have basically in aircraft, but it also applies again in space, because for instance, one of the stationary reactors, civilian reactor, has a power requirement of 231 megawatts. It requires a shield of about 2 million pounds to contain this radioactivity. This is the Shippingport reactor. It happens to come out at 231 megawatts (fig. 14).

A submarine runs around 70 megawatts and a shield weight of around a million pounds. It doesn't need to be this heavy but they can afford to use this particular weight, but we can't have this kind of weight in an aircraft, and quite obviously can't have this kind of weight in space devices.

So with an aircraft with a reactor in the neighborhood of 200 megawatts, we are working on shields in the neighborhood of 150,000 pounds, and I might say that we are talking about temperatures that are much higher, we are talking about temperatures, say, 2,500° or 2,600° Fahrenheit, versus the 700° Fahrenheit that you have in a submarine.

In the business of transfer of heat to propulsion, there are three different ways we go about this. Turbojet which is for the manned aircraft program. The Ramjet which is in the Slam-Pluto program, and rocket propulsion as in the Rover program (fig. 15).

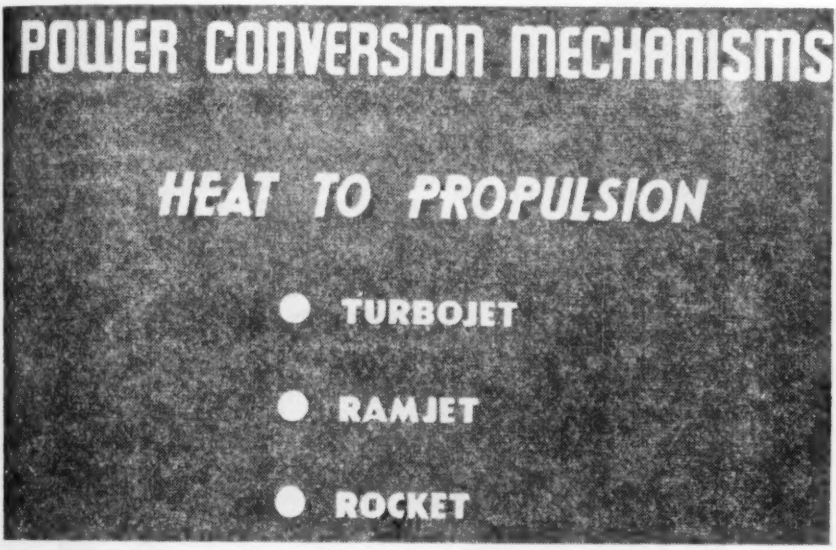

FIGURE 15

Very briefly, the two manned aircraft systems as I mentioned before, direct and indirect systems, basically the direct air system is a reactor in which air is heated up. It is passed through the compressor at the beginning of the engine, compressed to high compression ratios passed through the reactor where the air is heated and then put out through the turbine and out the duct in the form of thrust.

It is an oversimplification of the problem, but air being a poor heat transfer medium requires a larger reactor and, therefore, a larger shielding, so there are some very considerable problems in the shielding and weight restrictions that we have for manned aircraft.

In the indirect systems you use liquid metal, sodium, or NaK, which is a combination of sodium and potassium or some other liquid metal to transfer heat from the heat source within the reactor which can be much smaller by pumping it with a high-capacity pump through the reactor and back out some radiators which transfer the air coming through the turbojet engine and pass out through the duct in the form of thrust. These are basically the two systems (fig. 16).

This is a cutaway specialized view of the so-called HTRE 3, the high-temperature reactor experiment that we conducted recently out in Arco, Idaho.

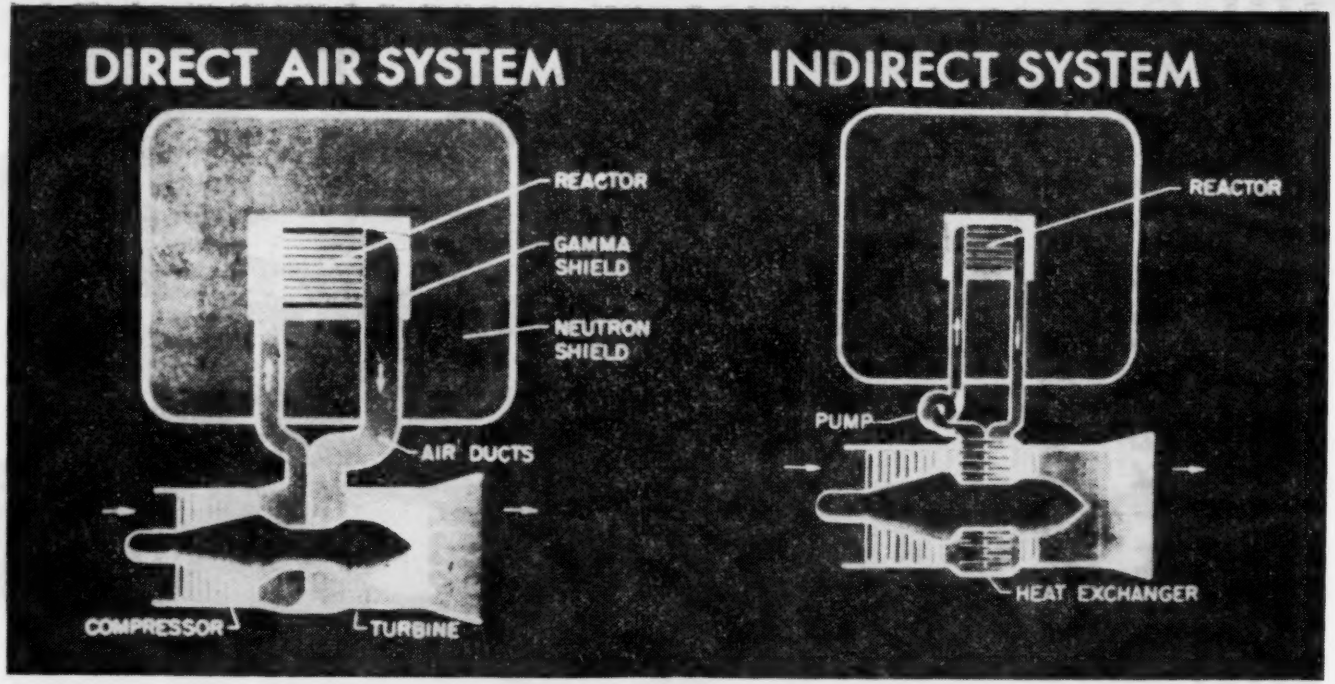
DIRECT AIR SYSTEM
REACTOR
GAMMA SHIELD
NEUTRON SHIELD
AIR DUCTS
COMPRESSOR
TURBINE
INDIRECT SYSTEM
REACTOR
PUMP
HEAT EXCHANGER

FIGURE 16

This has demonstrated the feasibility of the use of nuclear power for propulsion, whether it be for manned aircraft as in this case or for space vehicles. Having demonstrated this feasibility, we are now getting into specific applications which can be used for practical vehicles of various kinds (fig. 17).

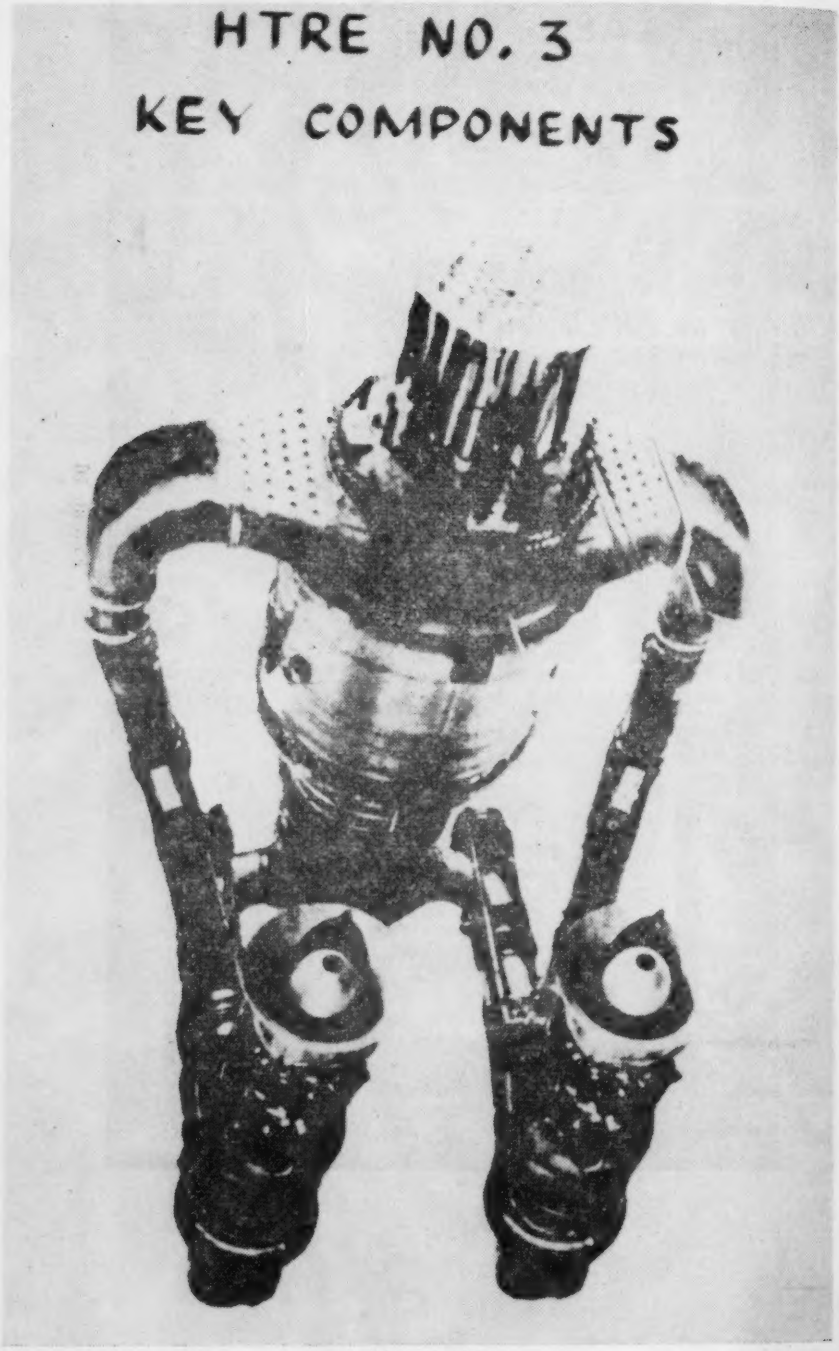

FIGURE 17

This is a cutaway view of the radiator which shows the intricacy and some of the mechanical manufacturing difficulties that the Pratt & Whitney people are facing in their attempt to solve the indirect cycle program. I might mention that one of the radiators they are working on contains some 4½ miles of three-sixteenths stainless steel tubing, so you can see there is a very serious manufacturing problem.

Now, to get into the unmanned systems. We mention what Slam was, the supersonic low altitude missile and Pluto is a device which is a nuclear-powered ramjet to power Slam (fig. 18, p. 422).

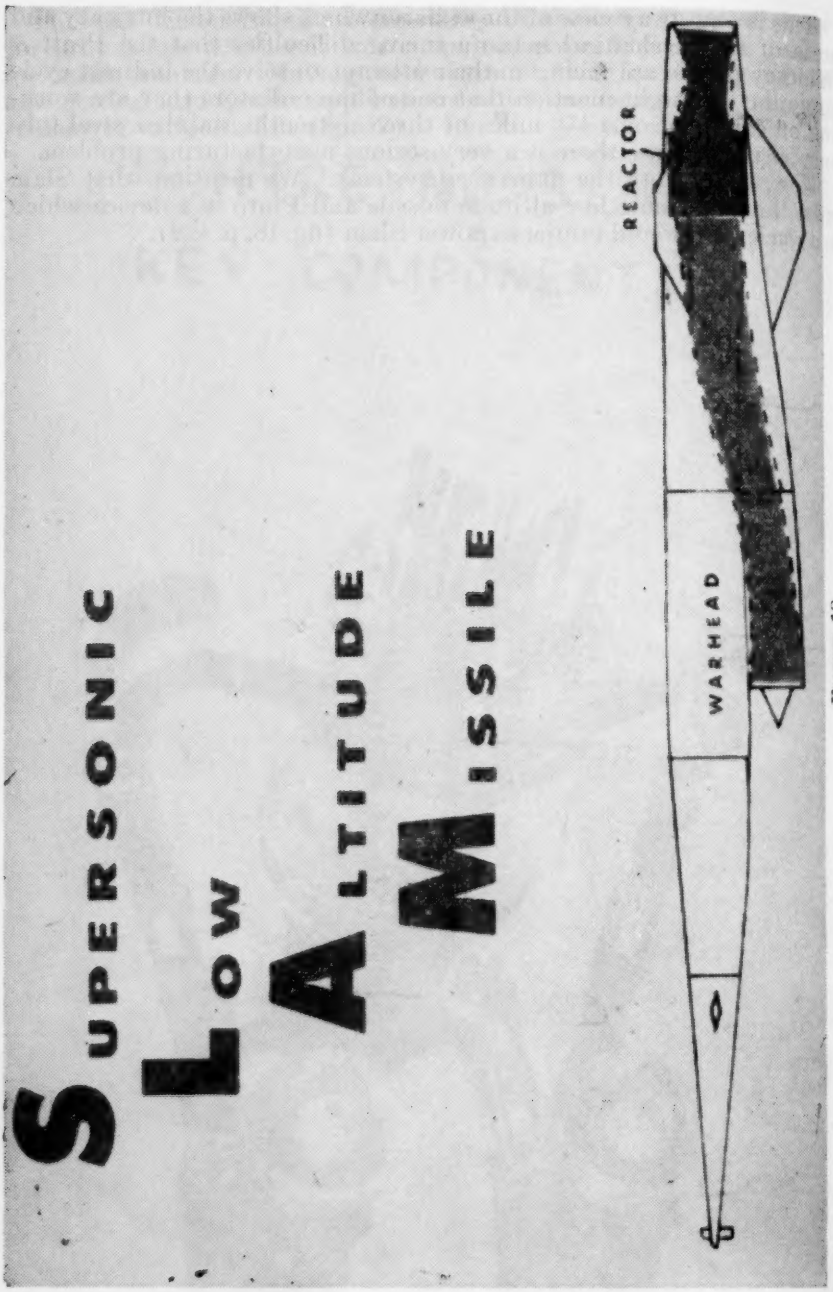

FIGURE 18

Here is a highly stylized version of this thing where air coming in through a duct under supersonic conditions passes through the reactor where it is heated and goes out the flue in the form of thrust.

Here is a cutaway view of a stylized drawing of what the reactor might look like with the air coming in passing through the reactor and going out the nozzle (fig. 19).

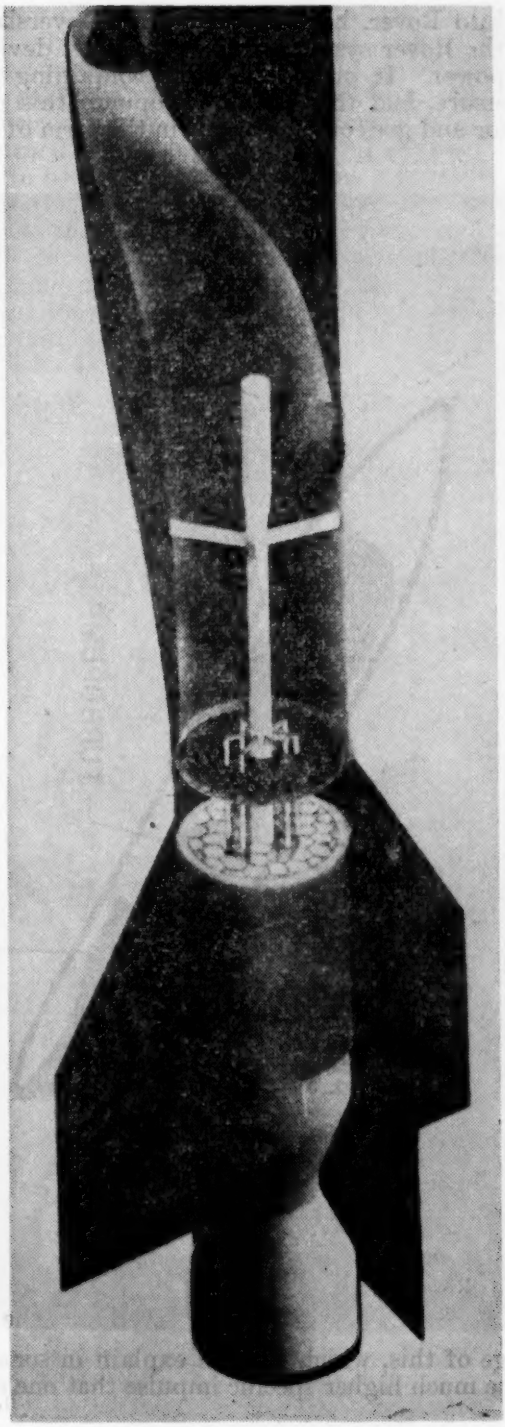

FIGURE 19

Now to get into Rover, here is a simplified—oversimplified, perhaps—view of the Rover system, which is a rocket device which employs nuclear power. It provides a tank containing gas which is kept under pressure, and through a turbopump this gas is passed through a reactor and goes out the nozzle in the form of rocket thrust (fig. 20).

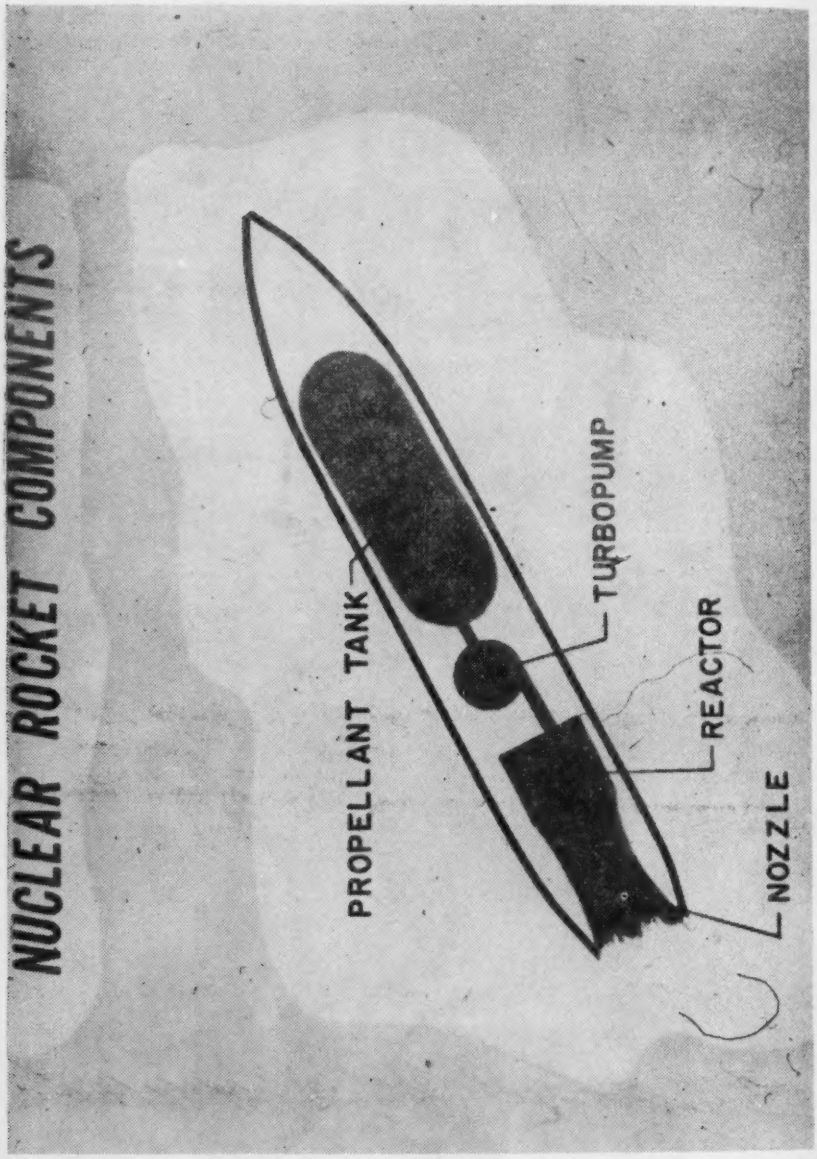

FIGURE 20

The advantage of this, which we will explain in some detail later if you like, is the much higher specific impulse that one might be able to get.

Here is a view of the Kiwi-A reactor which we demonstrated last July, the feasibility of this system out at Jackass Flats in Nevada. As I mentioned in the prepared statement, we exceeded our expectations in this particular thing, and, therefore, are able to go at a slightly faster pace than we expected originally to go in this particular device. It turned out to be a very useful device. It is, of course, not supposed to be a flying model. It has a nozzle on it because you have to collect the gases to measure temperature differentials. The plumbing is associated with getting gases and coolants and various other bits of techniques necessary, techniques into this thing in order to do the maximum amount of testing (fig. 21).

This has been done by the Los Alamos people working in Nevada.

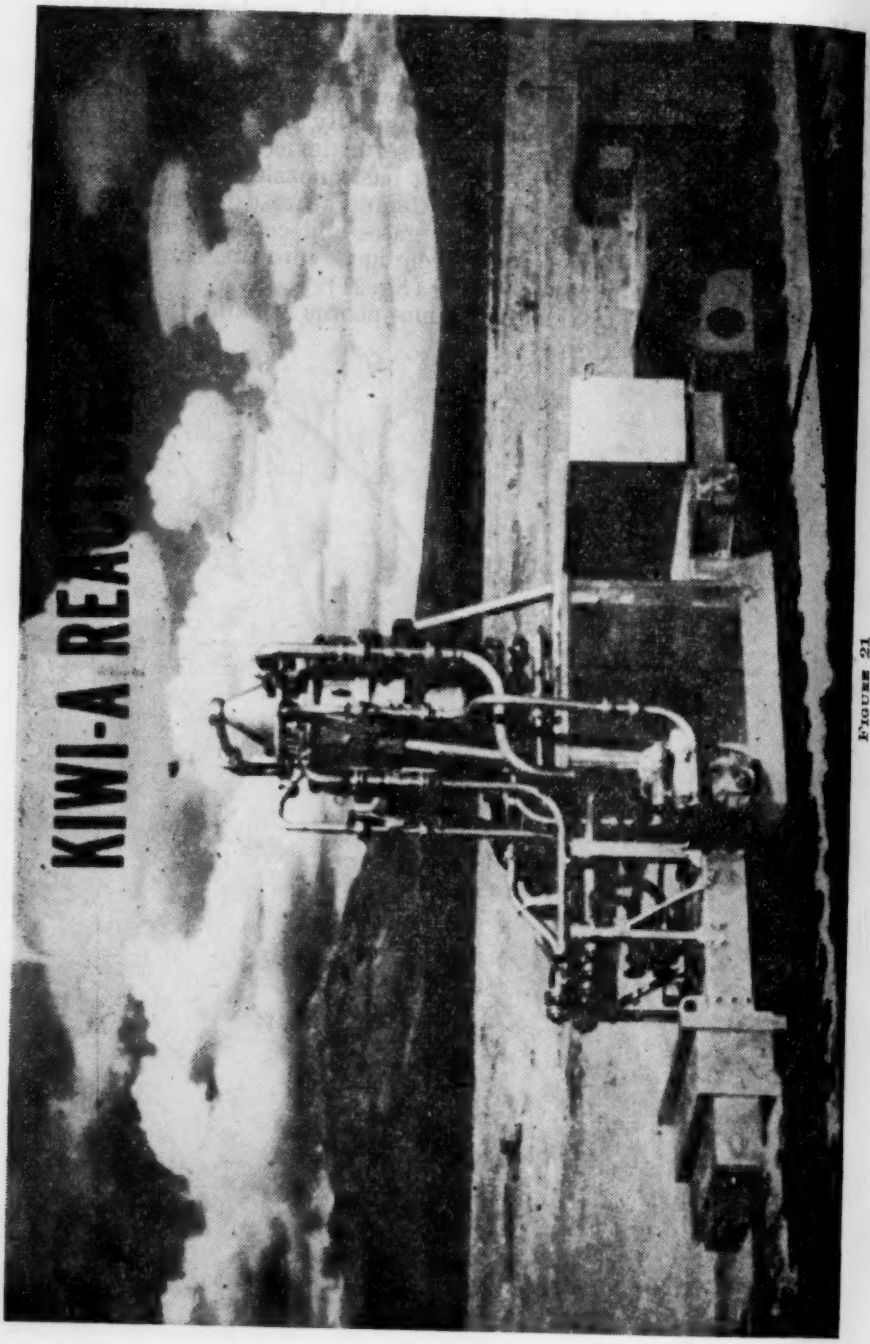

FIGURE 21

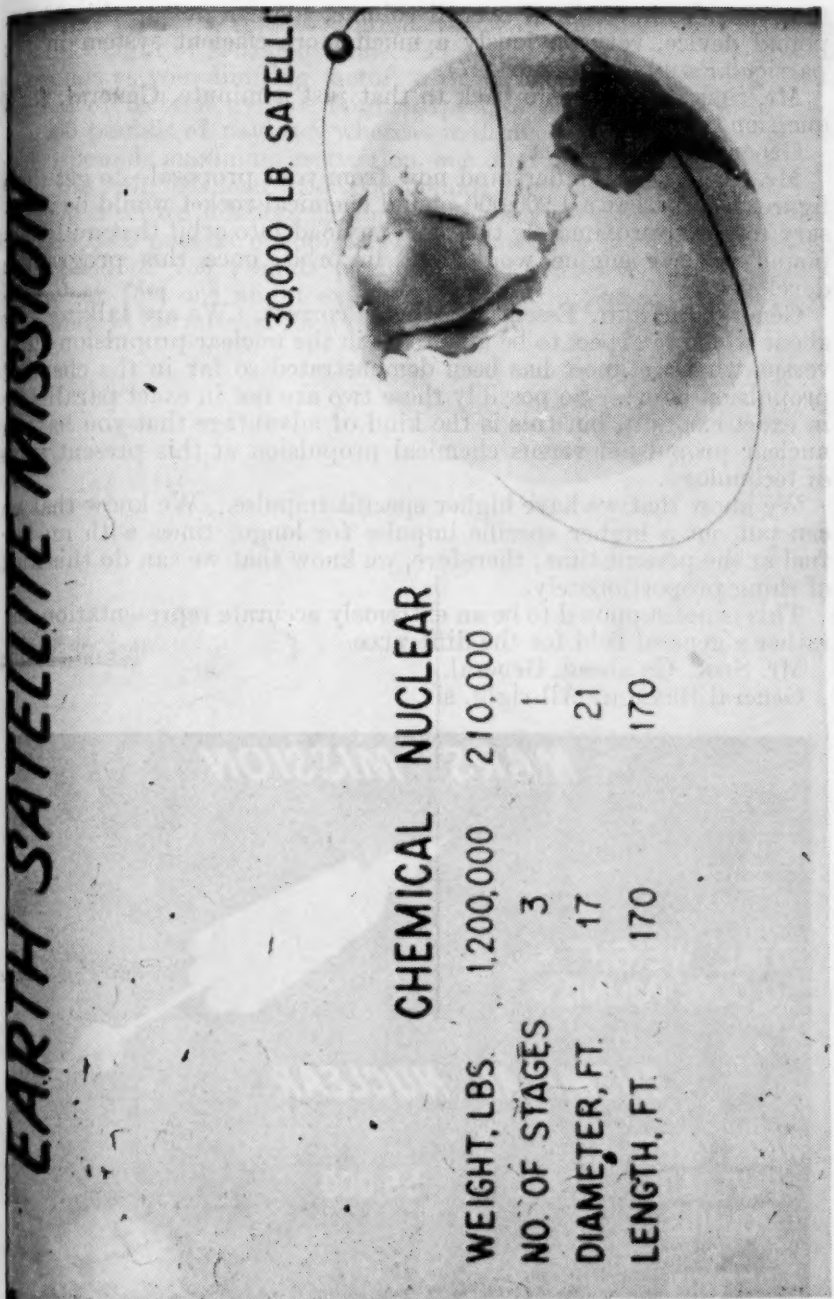

FIGURE 22

We are prepared to go into any detail you would like on what you would use these devices for, but I might mention that one study shows that if one wanted to put up a 30,000-pound satellite, we could do this in a variety of different ways, with three chemical stages, with a total weight of 1,200,000 pounds, you could put up this 30,000-pound satellite, but with one nuclear stage weighing 210,000 pounds, in about

the same size in terms of overall volume, you can put up this 30,000-pound device, very obviously a much more efficient system in this particular study (fig. 22, p. 427).

Mr. SISK. Can you go back to that just a minute, General, for a question?

General BRANCH. Yes.

Mr. SISK. Did I understand now from your proposal—to get those figures clear—that a 1,200,000-pound chemical rocket would be necessary to put approximately the same payload into orbit that a 210,000-pound nuclear engine would put in orbit, once this program is developed?

General BRANCH. Essentially this is correct. We are talking now about what we expect to be able to do in the nuclear propulsion effort versus what we know has been demonstrated so far in the chemical propulsion effort. So possibly these two are not in exact parallel, or in exact example, but this is the kind of advantage that you have in nuclear propulsion versus chemical propulsion at this present stage of technology.

We know that we have higher specific impulse. We know that we can put out a higher specific impulse for longer times with nuclear fuel at the present time; therefore, we know that we can do this kind of thing proportionately.

This is not supposed to be an extremely accurate representation, but rather a general field for the difference.

Mr. SISK. Go ahead, General.

General BRANCH. All right, sir.

FIGURE 23

Here again is what one might see with the Mars mission with a total weight of 150,000 pounds. If you had a total weight of 150,000 pounds as your limiting factor, with chemical fuel under the present state of technology, one might expect to put into Mars orbit about 7,500 pounds of payload, whereas with nuclear fuel within this 150,000-pounds maximum restriction, one might be able to put something in the neighborhood of 55,000 pounds payload (fig. 23).

On a return mission, again with the restriction of an overall gross of 150,000 pounds, one might expect something possibly in the neighborhood of 750 pounds payload under chemical fuel, whereas in nuclear fuel one might expect to be able to put as much as 25,000 pounds in the mission for a return payload.

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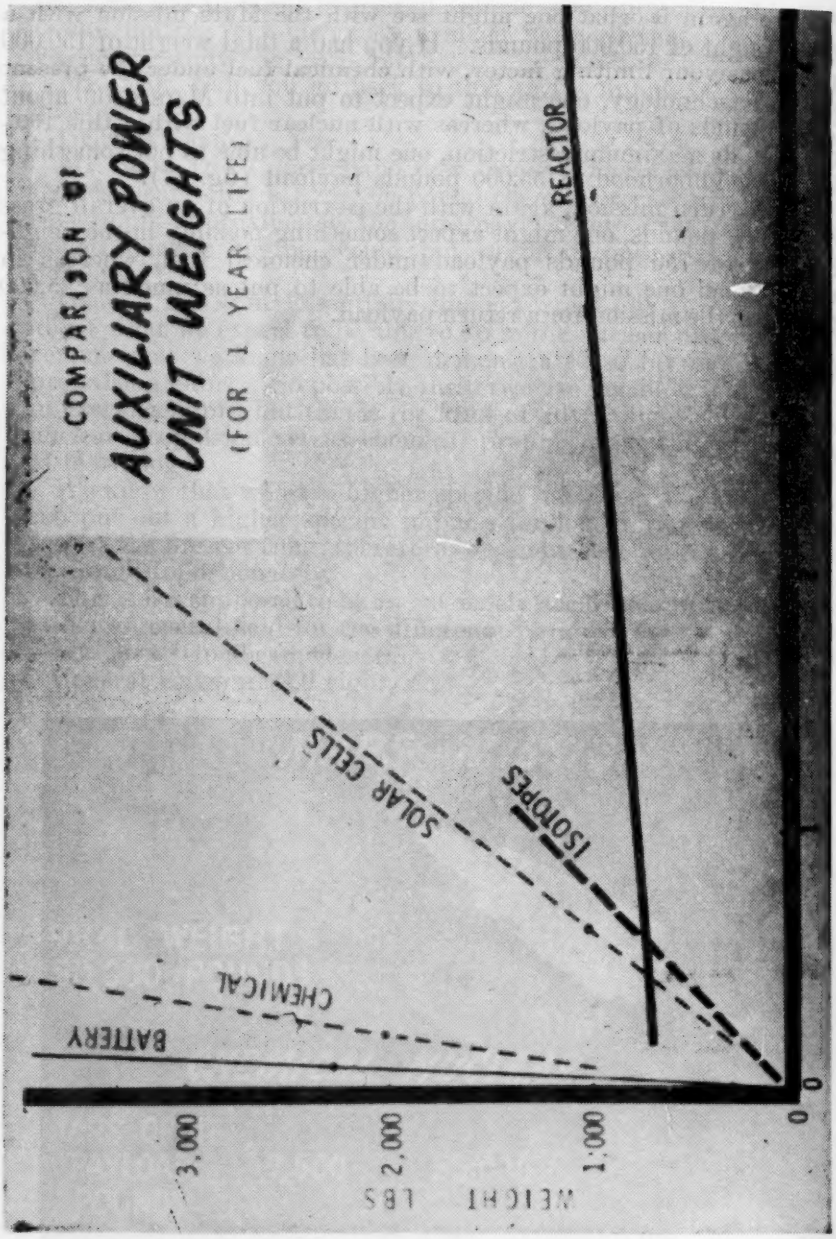

FIGURE 24

This particular chart shows auxiliary power unit weights for a 1-year life, and shows the advantages graphically of the use of reactors in isotopes versus the uses of batteries, chemical cells, and solar cells. As you can see on the bottom line here, the power is charted in kilowatts of power up to 4,000 watts or 4 kilowatts (fig. 24).

Going up in weight, as you can see, as soon as you get up over a thousand pounds, you go up very rapidly in weight for very little gain in power, under battery power, for example, you can't get up more than just perhaps 10 watts before you have gone way out of proportion in weight.

In chemical fuel, chemical power, for unit weight for a 1-year life and of course, the 1-year life is a specialized restriction, it possibly is not fair to measure it in these terms, but if one wanted to use power for a year at a time, in order to use chemical fuel, you can see you would have to get exorbitant weights in order to get any power at all.

Whereas with solar cells, you have a better system, but you have a lot of complexity with solar cells, themselves. When you get over a requirement of about 1 kilowatt as you see, you are getting up to to 1,500 pounds or more and the weights get pretty high. When you get into isotopes, as long as you are about 500 watts, isotopes do a fine job.

You can do that for somewhere in the neighborhood of 700 pounds.

When you get into requirement for megawatts of power, however, a reactor is the best system.

The reactor shows, you can get up to 4,000 or more watts of power for not more than a thousand pounds in your reactor.

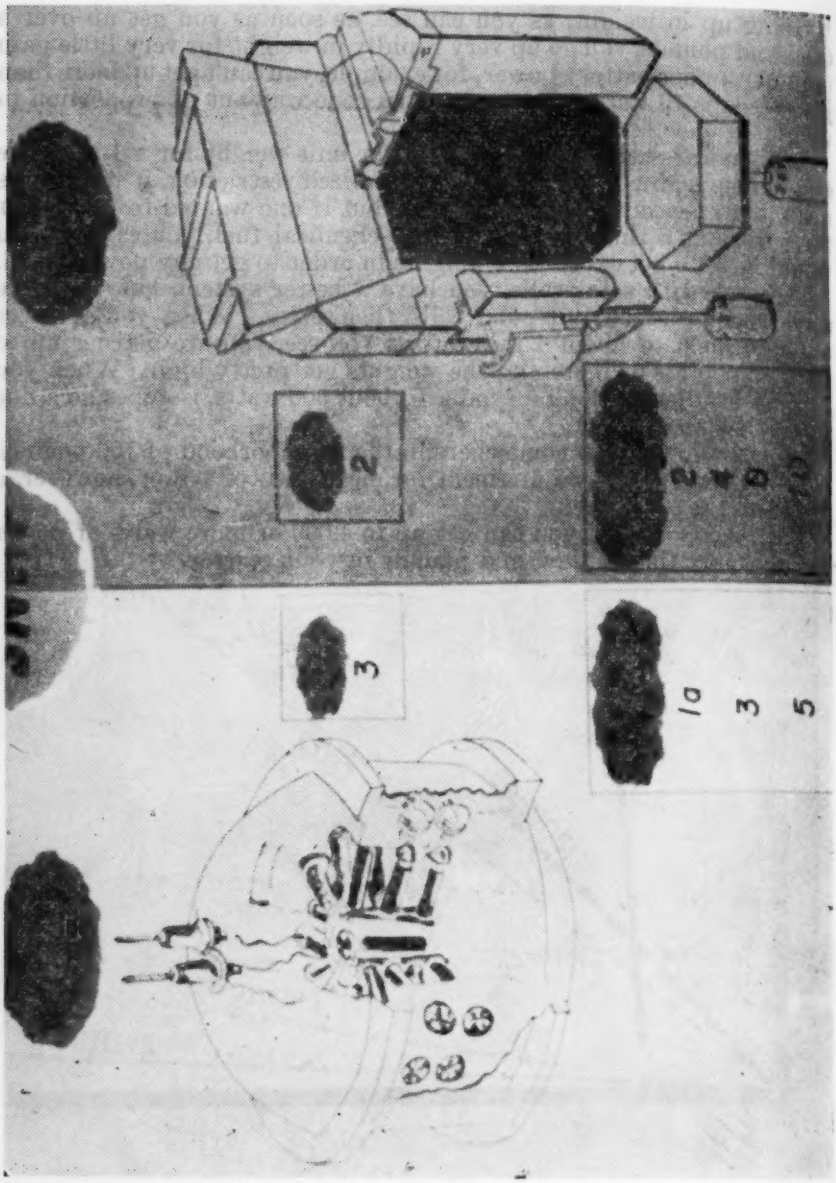

FIGURE 25

Now the Snap devices which Colonel Anderson and Colonel Armstrong will be able to give some specific information on, I would like to mention only that Snap devices are divided into odd and even numbers. The odd numbers as you can see here, denote isotope-powered reactors such as to one here on the table which is powering a little motor (fig. 25).

The even numbered Snap devices are reactors, which in general power turning devices and are limited by the ability of the turning devices to remain in a turning configuration, the bearings wear out, whereas the source of power never wears out, or almost never wears out.

So you have essentially an unlimited amount of power for generating the electricity or whatever source you want to use the power for.

I would like to turn this over to Colonel Anderson if I may.

Mr. SISK. All right, General, go ahead.

Colonel ANDERSON. As General Branch has indicated, there are two approaches to nuclear energy in space; radioisotopes and reactors. In all deference to solar energy, I would like to say from the past 5 years experience in this field, there is a place for all three in the space business. Certainly the crossover in power level is significant. One looks at a few hundred watts and decides whether he should use the radioisotope or whether one should use solar energy. We only stand ready to serve NASA should the situation arise.

The first unit of significance in the radiosotope development program is a small proof-of-principle model shown here, the model which is on the table has been running actively since last April. It is now approximately one-eighth or one-tenth of the original power, but as you can see, it is still putting out on the order of half a watt.

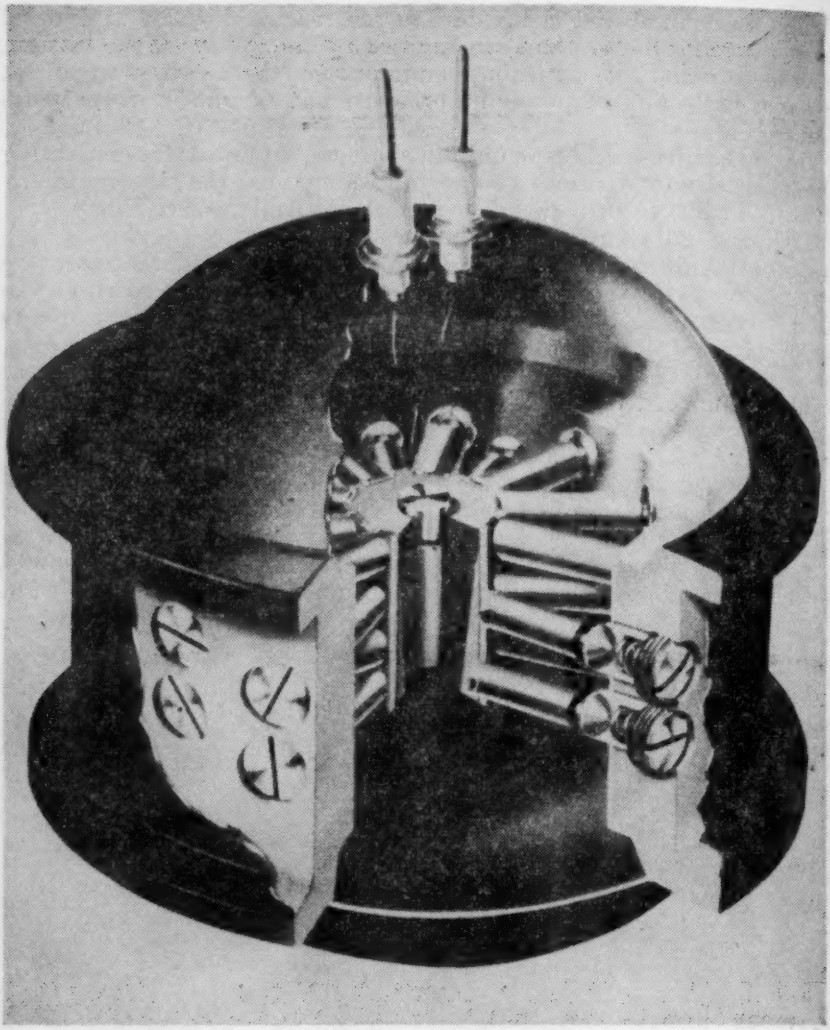

FIGURE 26

The cutaway shown illustrates the principles involved, the central portion containing a radioisotope, polonium 210, is contained in a very thick molybdenum sphere, triple welded to insure safety.

The cylindrical elements surrounding this are the means of converting the heat to electrical energy (fig. 26).

The whole thing weighs about 5 pounds, and is capable of producing 5 watts for a fairly long period of time.

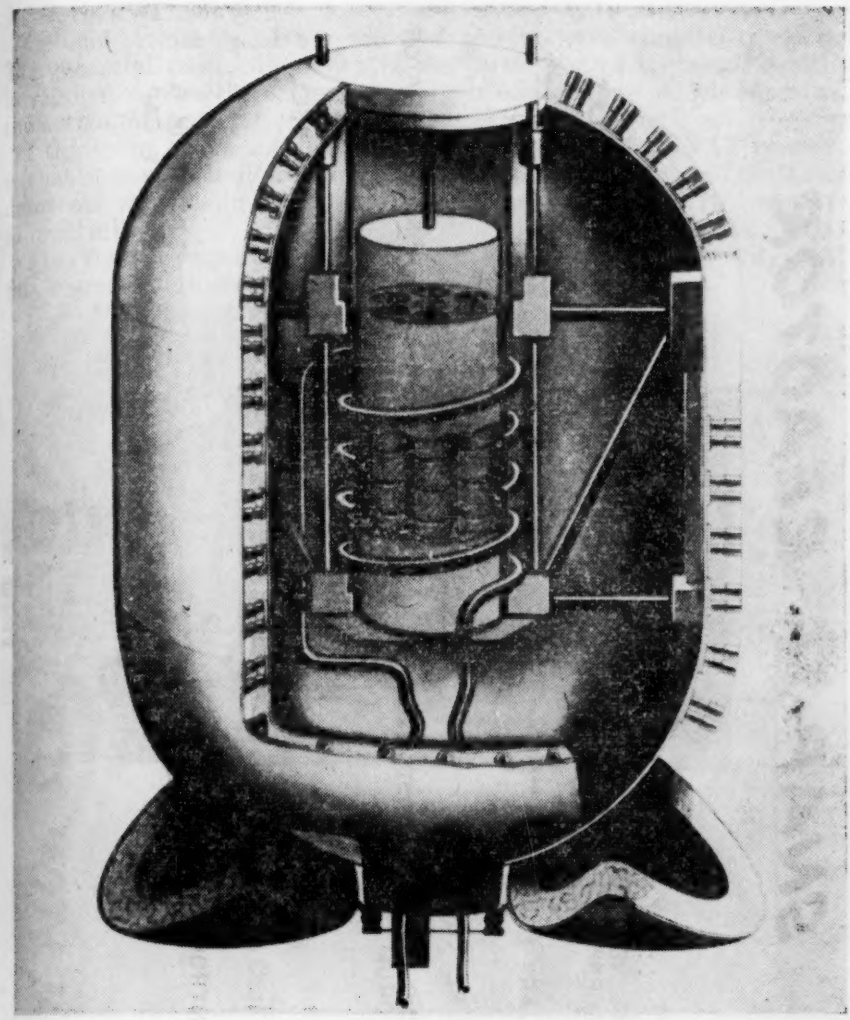

FIGURE 27

The next building block, the next unit that was built, based on this technology is the SNAP 1–A system shown here, which is based on the use of a more readily available isotope, namely cerium 144. This unit is about 3 feet long, about a foot and a half in diameter, weighs about 350 pounds, if two are used. One of these units weighs only 175 pounds (fig. 27).

This unit is actually being put together as a ground demonstration unit, and early next year should actually undergo a test using cerium 144 as the fueling material.

The outer skin as shown there contains the same thermoelectric materials that were used in the small SNAP 3 device.

The cutouts at the bottom illustrate how the excess heat can be dumped.

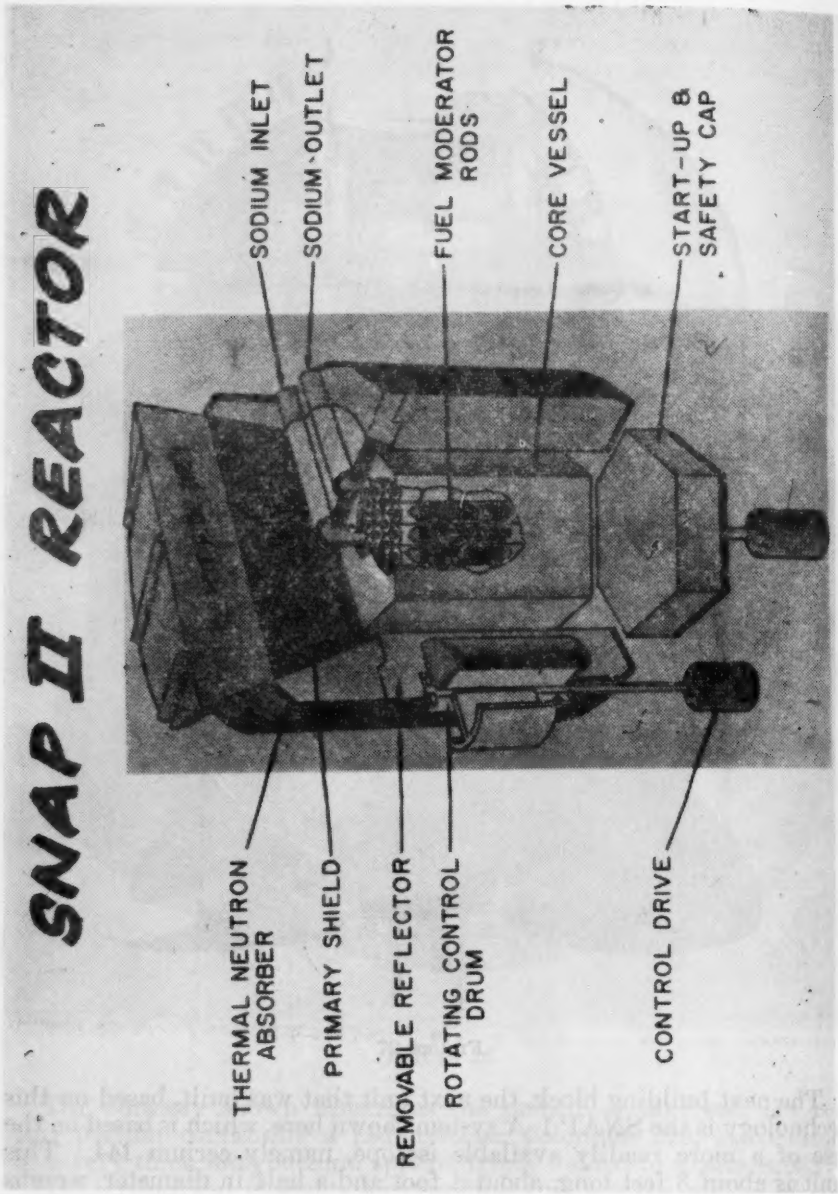

FIGURE 28

By far the most important project in the space power field, I believe, has been the development of the fuel element for the SNAP 2 reactor. This reactor is now running in a facility in California, and has successfully completed over 28,000 kilowatt-hours (fig. 28).

General BRANCH. I would like to explain, some of these slides, at the time they were made, were classified. As you can see here this one has been classified. It has since been declassified and we are not giving out information that should properly be classified.

Mr. SISK. Thank you.

Colonel ANDERSON. I am sorry, I should have made that clear. The essential parts are shown in the picture, with the small 8-inch hexagonal can in the center, roughly 10 inches long which contains the active material.

I think one of the most interesting things about the SNAP reactor is that it can be built economically, so when one thinks of putting numerous missiles in orbit, you are not starting out at a fuel cost of $1 or $2 million.

This reactor requires only 2.7 kilograms of fuel for criticality. A fast reactor might require as much as 60 or 70 kilograms.

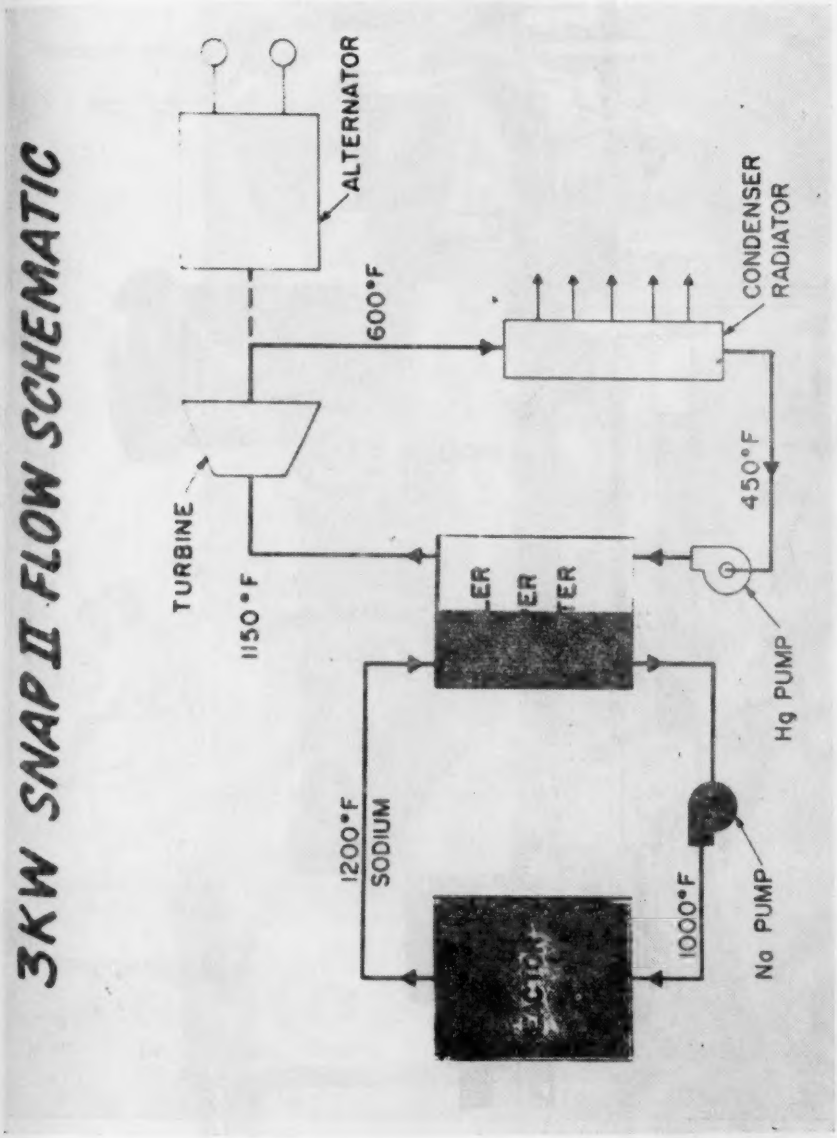

FIGURE 29

This reactor would be simply utilized in a very conventional heat cycle as shown here, using the reactor to heat initial loops of sodium, the heat would be transferred to a mercury cycle, this work is being done at Thompson Ramo Wooldridge while the reactor is under development at Atomics International (fig. 29, p. 437).

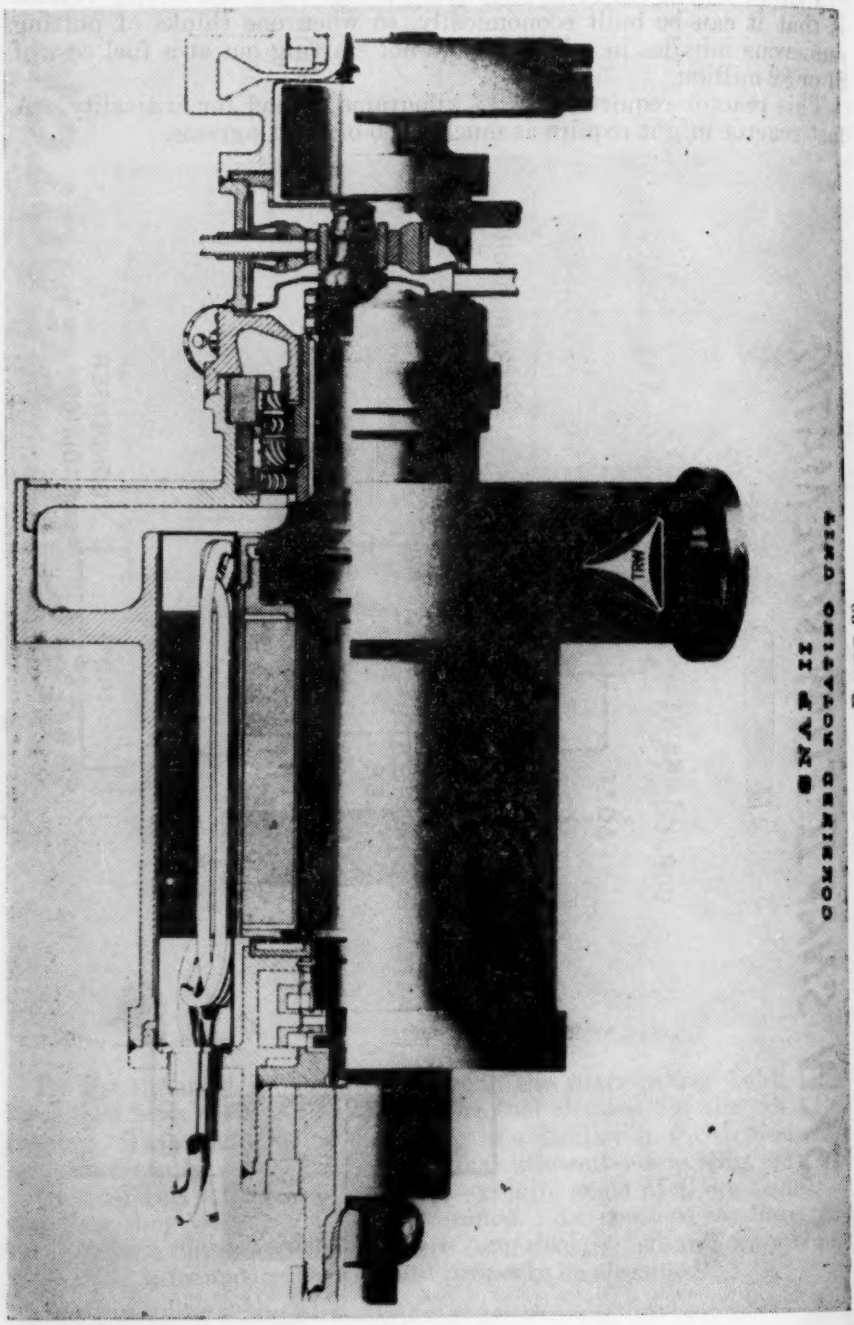

FIGURE 30

This is a cutaway of the rotating package which recently completed a 500-hour test successfully (fig. 30).

A full scale model of that is on the table in front of you. This embodies all of the rotating units in the whole system—the turbine, the alternator, the sodium pump, and a mercury pump. The shaft operates at 40,000 revolutions per minute, lubricated by mercury bearings, hermetically sealed.

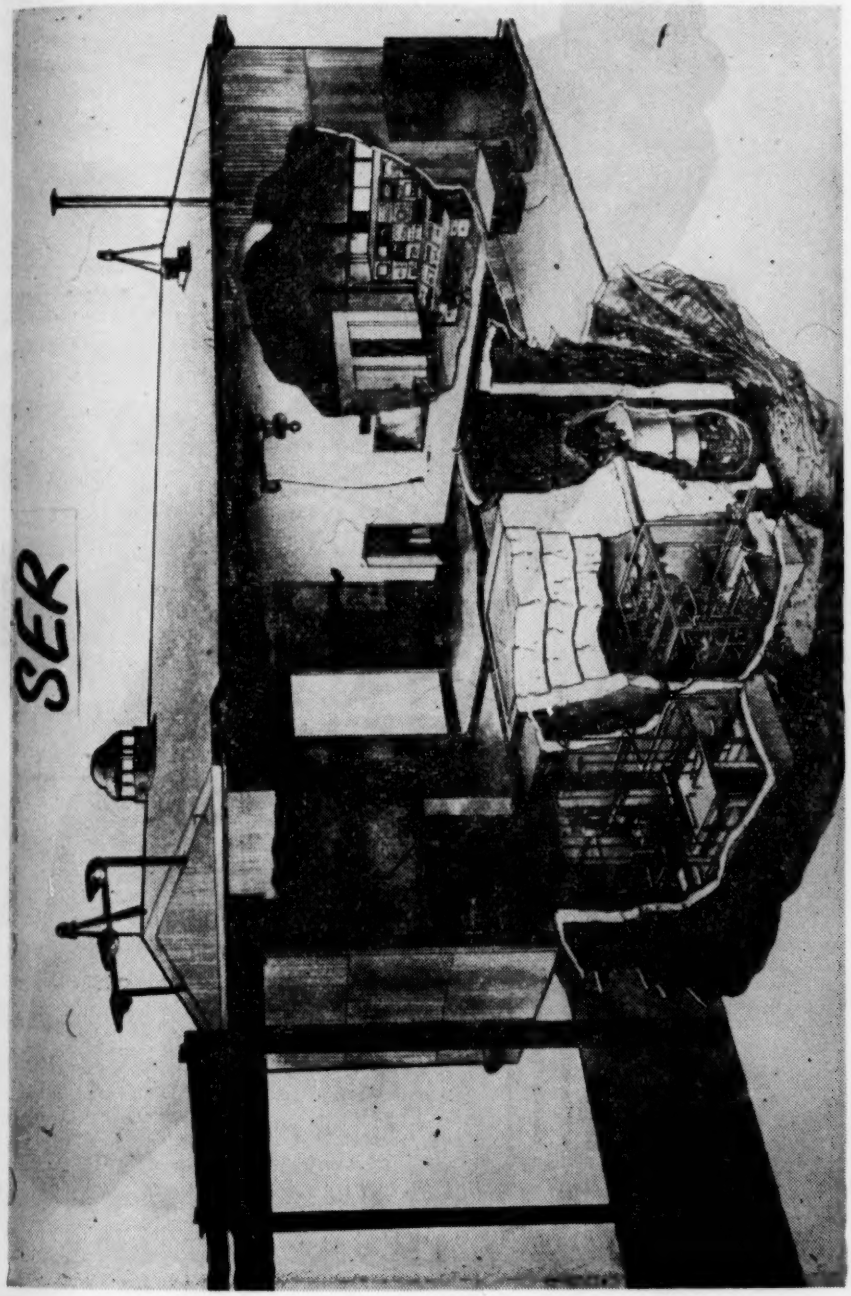

FIGURE 31

This facility presently houses the SNAP experimental reactor which has been under test now since last October. The reactor is shown at the bottom of the containment vessel. It is presently being prepared for a long endurance run. We have had no trouble with this reactor. It has achieved every goal that we have set for it (fig. 31, p. 439).

FIGURE 32

This is an artist's scheme of what this reactor would look like installed in a space vehicle. The unit would be suspended probably somewhere near the centerline with the necessary plumbing and rotating equipment housed in this same module (fig. 32).

The whole unit installed in this manner would weigh something like 500 pounds, exclusive of shielding—roughly 100 square feet of radiator area, which would be part of the skin, is included.

FIGURE 32

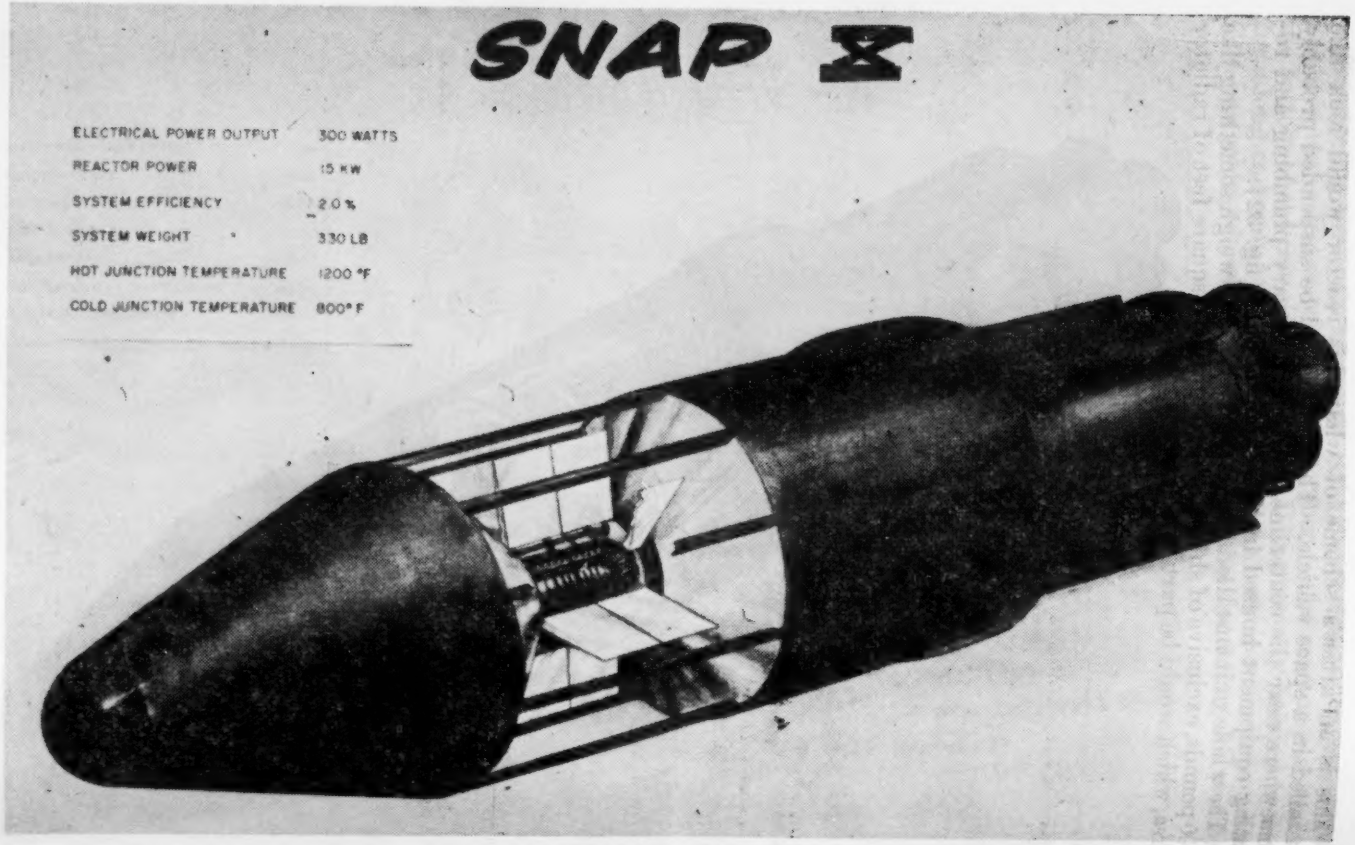
SNAP X
ELECTRICAL POWER OUTPUT 300 WATTS
REACTOR POWER 15 KW
SYSTEM EFFICIENCY 2.0 %
SYSTEM WEIGHT 330 LB
HOT JUNCTION TEMPERATURE 1200 °F
COLD JUNCTION TEMPERATURE 800° F

FIGURE 33

The SNAP 10 reactor is shown here in concept. It consists of the same fuel material made in this case in the form of disks, however, roughly 5½ inches in diameter, a core length of about 8 inches. The thermoelectric elements which are used in the SNAP 3 radioisotope generator are also used here (fig. 33).

This small unit would offer a great deal of flexibility in space. It could be placed almost anywhere in the vehicle if practical from a shielding standpoint. It would produce 300 watts of useful electricity practically forever, burning just a few grams of uranium per year.

This unit can actually be ready for use in 2 years if impetus is given to this program.

In contrast to solar energy, this offers a great deal of flexibility.

This would be a typical installation of this device in a vehicle. The weight here would only be 350 pounds (fig. 34, p. 444).

FIGURE 33

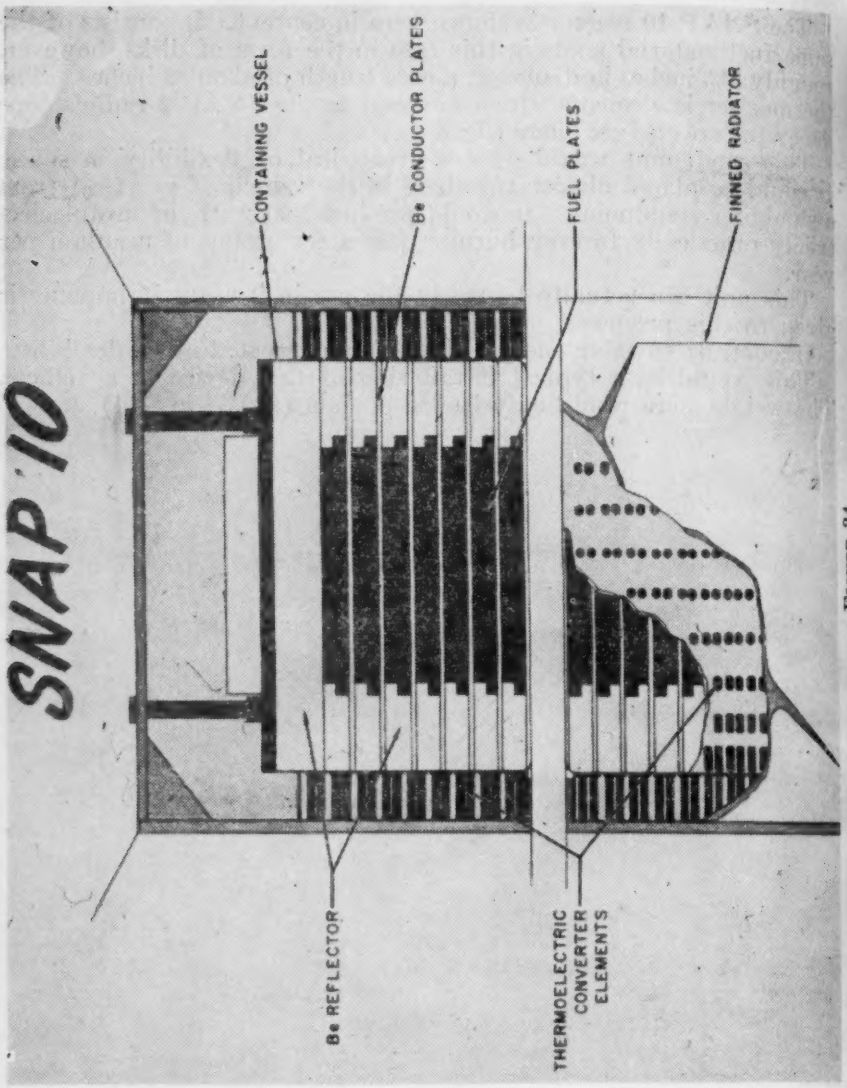

FIGURE 34

This is a cutaway of the Snap experimental reactor now under test. It is very similar to the model we have beside the table here. It is essentially a core test, which illustrates the feasibility of this concept and proves out the parameters that we feel are important.

This shows the growth that the Snap units are experiencing (fig. 35).

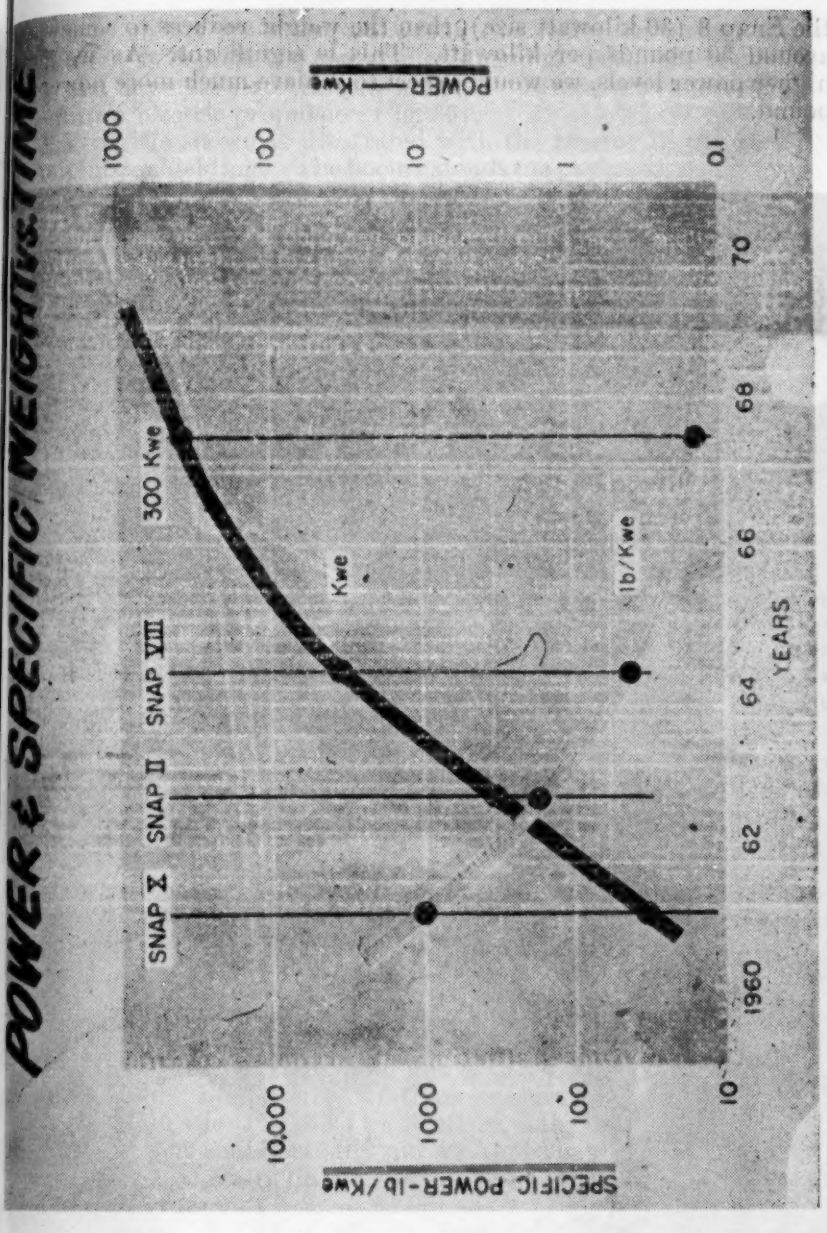

FIGURE 35

FIGURE 34

For example, a very important factor in space travel will be that of producing many kilowatts per pound of powerplant. This shows how the Snap 10, Snap 2, and Snap 8 equipment (that will be produced for NASA) will reduce this figure. For example, the Snap 10, 300-watt unit, requires some thousand pounds for 300 watts. This is because we are critically limited. But when one approaches

the Snap 8 (30-kilowatt size), then the weight reduces to somewhere around 50 pounds per kilowatt. This is significant. As we go to higher power levels, we would expect to achieve much more power per pound.

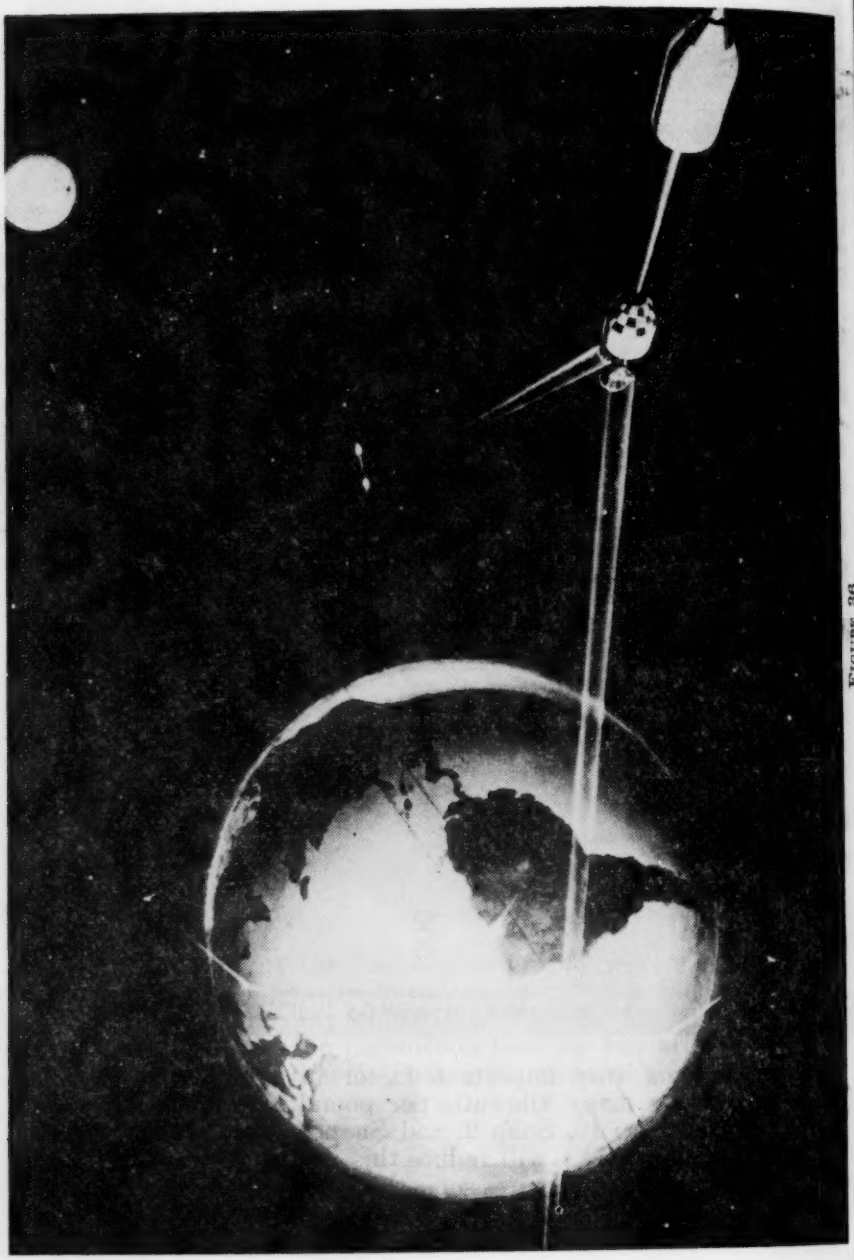

FIGURE 36

This is an artist's concept showing the utility of nuclear systems in space. It depicts the communications and reconnaissance aspects that are important for the use of such devices, and conceivably in the future, electric propulsion (fig. 36).

The vehicle shown is illustrated with the reactor in the very nose to minimize shielding. The boom extends the payload.

This is the extent of my comments.

General BRANCH. I would like, sir, to make one correction, or rather to clear up what possibly might be a misunderstanding in what Colonel Anderson said about the Snap 10.

He mentioned that it could be ready in 2 years if proper impetus were given to its development or requirement. I think possibly this might be a misleading statement. What, in effect, he meant is that if a requirement is developed for this particular thing, we can have it ready to meet this requirement within 2 years.

It isn't a matter of not having enough impetus, it is a matter of having something before a requirement is ready for it. In some cases we are fortunate enough to be a little bit ahead of the compatibility with the vehicle.

We would be working very hard on most of these reactor devices within the Atomic Energy Commission even if there were no requirements for them—immediate requirements for them—because these techniques are new and novel and have a tremendous amount of potential later on.

Almost all of the military reactors are reactors which have civilian applications, either now or in the future, and, therefore, we would be required by the Atomic Energy Commission to go ahead with some sort of development level on these things, even though no specific requirement were ever stated at this time.

Mr. SISK. Well, I might say, General Branch, that I appreciate those comments.

You see, basically, our committee is concerned with the consideration of the authorization bill. We are being called upon, of course, to authorize the expenditure of what amounts to hundreds of millions of dollars for the development of liquid rocket engines.

I am sure you are generally familiar with the F–1 engine, and NASA's contract with Rocketdyne. The fact is that apparently somewhere in the future will come the actual completion and full development of that million or million and a half-pound thrust engine, and the possibility of a cluster of those engines to create the so-called Nova configuration. This, I understand, is the only project at present in the mill that could actually put a manned exploration on the monn for example, or really do some of the things that we hope to accomplish in the future.

There again, NASA is talking about the year, 1970, or the decade of 1970's, rather than in the 1960's.

Our committee is interested in what is happening in your field of endeavor and to what extent maybe some of this money should be concentrated in that field in preference to the liquid rocket engine development.

Don't misunderstand me, I have no desire to cut back. I have been asking that both Saturn and the F–1 be expedited, as I understand these projects present the only possibility of really getting a lot of

trust in the super boosters. But we have heard here about certain developments that you have made. It seems to me that your testimony would indicate some rather substantial progress recently in this field.

General BRANCH. Yes, sir.

Mr. SISK. Would you comment to what extent you think that we should make long-range commitments for the expenditures of hundreds of millions of dollars over periods of 8, 10, 15 or 20 years in the future, on liquid rocket engines, as against the possible advancement in nuclear propulsion?

General BRANCH. I would like to pass this to Colonel Armstrong. I would like to say first, though: I would be doing a disservice if I left the impression that we are recommending the substitution of nuclear power for chemical power.

If I were given this impression, I have done it inadvertently. I didn't mean to do so.

Mr. SISK. I appreciate that. I am sorry if my statement indicated I inferred that from you. I did not wish to infer you were seeking that. We have a lot to do in both of these fields. I don't necessarily say one would replace the other. I think they should be tied together. We are concerned how your development in nuclear propulsion can be tied in with the progress in the other fields and all together be made to do the job quicker and better.

General BRANCH. Colonel Armstrong is a member of the coordinating group he mentioned earlier, and is working on this particular problem with the NASA people and others to be sure we do have proper compatibilities. He can give some specific information on it.

Mr. SISK. All right, Colonel Armstrong, go right ahead.

Colonel ARMSTRONG. I am going to try to oversimplify a very complex problem.

To prove the feasibility of a nuclear rocket engine is in itself an extremely expensive business. The budget which we have requested this year is some $20 million worth of construction funds, and pretty narly $23 million worth of operating money.

If we get these funds for this coming year, I think it is as much money as we can usefully spend in this business.

When we have proven the feasibility and the engineering capability of this nuclear rocket engine, we have done so in a power range which would allow this nuclear rocket engine to be taken and used as an upper stage on a chemical system. To this extent, these are *very complementary things.*

By combining chemical boosters, large chemical boosters, with nuclear upper stages, you can get large incremental increases in payload.

Now, on the other hand, to achieve the kind of a mission which you saw on the chart a few minutes ago, where we were putting 30,000 pounds of payload out into an orbit, in an over-vehicle, a nuclear vehicle that weighed some 210,000 pounds, we are talking about nuclear power in a reactor of something like 14 to 15 thousand megawatts.

Now, as a purpose of comparison, this is a reactor which is about the size of this table, and it contains more power than Boulder Dam. It is not the first step in the nuclear rocket business.

It is, though, indeed, a natural and direct outgrowth of the power levels that we are operating at at this time.

The device which we will come out with first will allow itself to be extrapolated either way. You could go down in power, use this as an upper stage for very long planetary missions, or you can extrapolate the other way and go to very high powers, where you would go down so far as using it as a booster.

But these things are out in the distance. The type we are working on right now is close-in. We do feel very strongly, and I suppose being involved in the business, one always gets very strong opinions. We do feel that a nuclear device can be flown in the relatively near future and do a useful mission and prove-out many of the things that we need to know as General Branch mentioned earlier, to go these other directions.

So I would not say that the nuclear system is a substitute in the foreseeable future for chemical systems. I think they are very compatible.

I would hesitate to prognosticate that they would never be a substitute for a chemical system at sometime in the future.

Mr. SISK. Let me conclude my questions by simply asking this one question, Colonel Armstrong, of both you and General Branch.

Are you completely satisfied with the emphasis that NASA is placing on nuclear propulsion in its overall program?

General BRANCH. I think, sir, that I personally would have to say no. I think, though, that in the work that we are doing with the NASA people at this time, that the NASA people will come up with the requirement that will speed-up the matching-up of our capability with their requirement so that we will be satisfied.

At the present time the specific requirements that we have are not to me satisfactory, and we can go faster than they want us to right now. We are working, as I say, we are working with these people, and I think before long we will have a specific requirement.

Mr. SISK. Do you believe, General, then, you can sell them on the possibility?

General BRANCH. We are trying to very hard, yes, sir.

Mr. SISK. I appreciate that as being a very frank statement. That is what I wanted. I know you intend no criticism of NASA or anyone else, because these matters are, of course, matters of judgment, where they must allocate such funds as are available to them in the best manner possible.

I know there has been some concern on the part of many people that a little more emphasis should be placed in this field. And this was the principal reason that we were particularly anxious to hear you people this morning prior to our passing finally on this portion of the budget, and to have an opportunity this afternoon, to discuss a little further this matter with NASA representatives.

The gentleman from Indiana.

Mr. ROUSH. A couple of questions concerning this gadget we have here on the table, General.

Is that what you call a model of Snap 2?

General BRANCH. I don't know which one you are referring to, Mr. Roush.

Mr. ROUSH. What is Snap 2, the big one?

General BRANCH. Yes, sir, the big, full-scale model of the big one. Fortunately, it is a wooden model.

Mr. ROUSH. How large actually is that?

General BRANCH. This is a full-scale model.

Mr. ROUSH. That is full-scale?

General BRANCH. Yes, sir.

Mr. ROUSH. How much does it weigh?

General BRANCH. 300 pounds. It develops 125 watts of power.

Mr. ROUSH. In your statement, you stated you could——

General BRANCH. I beg your pardon. 3 kilowatts of power. 3,000 watts of power.

Mr. ROUSH. You stated you have a full-scale model of the Snap 2 reactor to provide an engine that can be converted into 3,000 watts of electrical power for periods of at least a year.

General BRANCH. Yes, sir.

Mr. ROUSH. Is that capable now of doing that?

General BRANCH. Yes, sir.

Mr. ROUSH. You don't have to do anything with it to make it do that?

General BRANCH. No, sir.

The reason we say a year, Mr. Roush, the thing is capable, as Colonel Armstrong said, of putting out power almost forever. It is a matter of mechanical devices to convert this power into useful energy, and therefore not a matter of putting out power. The life of the rotating mechanisms is a governing factor. We say a year as a safe limit. If the bearings will stand up.

Colonel ARMSTRONG. Let's go back a year. I believe I appeared in executive session before this committee just almost a year ago, at which time the only device which we had operating and which we could point to with any degree of pride was the SNAP 3 device which had just been unveiled a month earlier.

In that executive session I showed you a schematic of this SNAP 2 reactor, and said that this we hoped to get on test this year. I also showed you a schematic of the Kiwi-A reactor for Rover, which I said we hoped to get on test this year.

One of the big problems about the nuclear business is, unless you can prove it, you have many doubting Thomases, because the nuclear business has been fraught with many problems.

Today we can prove these things. This SNAP 2 reactor has now been operating for 30 megawatt-hours. It has exceeded all of our expectations. It is far beyond anything which we had a right to expect.

This rotating package which you see on the end of the table here is the complete generator, turbine, and the works. That has operated now for 500 hours, and is operating very well.

The next step in this program is to "marry" that rotating package with this reactor. This is a rather straightforward deal.

At the moment this reactor is pumping its heat out into a large radiator and being dumped into the atmosphere of California.

This rotating package is operating in Cleveland, and it knows not where it gets its heat, and it cares not where it gets its heat. The marriage between the two is the next natural step.

This little package you see before you here in the plastic is the turbine for this rotating unit.

This turbine has an alternator, the little balls you see on the end are bearings, which are quite an advance in the art, because they run in the mercury that runs the turbine, and we have run these for hundreds of hours, with no perceptable sign of wear on them.

The little tiny thing you see sticking out on the right end there is a pump, and it pumps all of the mercury through this entire system. This is quite a step forward in the art, too. You see it is no larger than a pencil.

This is a proven package. All we have to do now, marry it, subject it to all the shock tests and everything that you would expect, the environment that you would expect, and it is in business.

Snap III is in business. It is ready for the customer.

Mr. ROUSH. Snap III, is that the unit?

Colonel ARMSTRONG. This is the small black unit that you see here.

Mr. ROUSH. Has any of this ever been used in a satellite?

Colonel ARMSTRONG. No, sir.

Mr. ROUSH. Can you tell me why not?

Colonel ARMSTRONG. The very easy answer, of course, would be to say I don't know.

But actually it isn't quite that clean cut.

This Snap III unit that I say has been operating for a year now, has been given all of the shock vibration tests that are necessary to make it an operational device.

There is a degree of hazard, if you will, in the use of any radioactive material. This particular device has been tested under every condition that we can think of to destroy it, and we have not yet been able to destroy it.

For instance, we fired it down a track at Aberdeen, at 1,100 feet per second. We preheated it to 1,700° F. and rammed it into a solid granite wall. We fractured the wall into many, many pieces and we didn't hurt the unit a bit. So we think we have a very safe unit.

On the other hand, there are other facets to this. Satellites do go up, but satellites do come down.

I think it would be very disturbing to international relations if we dropped this radioactive unit in the Kremlin. So one must make many studies to make sure that this unit can be safely put into space, can be dispersed in space upon the completion of its mission, and this we are doing.

So my answer, "I don't know," isn't quite an easy answer. There are reasons.

General BRANCH. It is primarily, I suspect, a political problem rather than a mechanical problem that causes us to say that we have not yet put one of these things into orbit.

Mr. ROUSH. We have immediate plans to use any of these in any satellites at all?

General BRANCH. No, sir.

Mr. ROUSH. That is considerably smaller than a solar unit?

General BRANCH. Yes, sir.

Mr. SISK. We are very happy to have the chairman of our full committee here with us this morning, and I certainly want to give him any opportunity to make any comments he wishes to make.

Mr. BROOKS. Fine. Well, we are glad to see the subcommittee so diligent, working so hard. I hope they come in with a report soon so we can get our authorization bill on the floor.

General, let me ask you this:

What prevents you from using something of that sort immediately? What mechanical reason prevents you from using a machine of that sort immediately in a nuclear airplane?

General BRANCH. Sir, it doesn't lend itself to the kinds of power levels that one needs for propulsion of a nuclear airplane. It just doesn't happen to be compatible mechanically with the power levels one needs for a nuclear airplane. We are talking here in these devices in the relatively low kilowatt range, versus a great many hundred megawatts of power that we need for propulsion of nuclear aircraft.

Mr. BROOKS. You have 300 pounds there for 3 kilowatts?

General BRANCH. Yes, sir.

Mr. BROOKS. That is about the ratio. It is about 100 pounds per kilowatt.

What ratio would you have to have to be mechanically feasible in a plane?

General BRANCH. It is considerably less, sir. I would guess it is a third of the weight per power ratio.

Mr. BROOKS. So you have to get yours down to around 30 pounds per kilowatt.

General BRANCH. Actually 1 pound per kilowatt would be closer to what we would hope to achieve eventually for useful flight.

Mr. BROOKS. That is one one-hundredth of what you have there.

General BRANCH. That is correct.

Mr. BROOKS. Thank you, Mr. Chairman.

Mr. SISK. The gentleman from New Mexico?

Mr. MORRIS. Mr. Chairman, I just wanted to ask one question.

I was under the impression that when these satellites reentered the atmosphere, they were destroyed.

General BRANCH. Yes, sir. Normally if this thing were to reenter the atmosphere as having come back down out of orbit it would burn up in the atmosphere.

Mr. MORRIS. How would you have the problem of it landing in Soviet Russia if it disintegrated whenever it hit the atmosphere?

General BRANCH. It wouldn't, Mr. Morris, but if it failed to get into orbit for some reason—I mean we have to count on the problem of mechanical difficulties so that we would fail to achieve the flight configuration that we want, and therefore we have to expect difficulties or disaster, if you will.

Mr. MORRIS. Don't you have some method of destroying it?

General BRANCH. Yes, sir.

Mr. MORRIS. Whenever you make a shot, I was under the impression we had a method of destroying them.

General BRANCH. Yes, sir, but you see one of the problems that the people who would be firing these kinds of things would have to face up to, is when they destroy advanced stages in devices that are being fired, for example, from Canaveral they blow them up, and that is, you might say, the end of it. The material that is blown up falls into the water, and sinks into the water. Whereas if this had to be blown

up shortly after it got off the launching pad, you would possibly scatter—I say possibly rather than probably—you would possibly scatter very high radioactive material around and it would cause a nasty cleanup problem in that the radioactivity might fall in a fishing area, and you would have to worry about the political problem of contaminating water where commercial fishermen activities occurred.

Mr. MORRIS. Of course, you have problems at any time you undertake any type of new operation. You always have problems, similar problems, don't you?

General BRANCH. Yes, sir.

I am only explaining, Mr. Morris, what the kinds of problems are, not that we think these are governing problems. Of course, as Colonel Armstrong said we are very enthusiastic about these devices and we feel they could be used right away.

Mr. MORRIS. You don't have any problems you don't think could be overcome, do you?

General BRANCH. That is correct.

Mr. MORRIS. That is all, Mr. Chairman.

Mr. SISK. The gentleman from California has some questions. Mr. McDonough was unfortunately delayed in getting down, General Branch. He has been reviewing your statement here.

Mr. MCDONOUGH. I am sure I didn't hear your complete statement.

During our subcommittee discussions on this particular matter the question I raised was the weight of these as an operating unit.

How much thrust would we need to put one of these into orbit?

General BRANCH. If I may, I would like to ask Colonel Armstrong, because he knows specific answers and I know only general answers.

Colonel ARMSTRONG. I assume you are asking about the Rover nuclear rocket device.

Mr. MCDONOUGH. That is the only one we are actually working on, isn't it?

Colonel ARMSTRONG. We were previously talking about the auxiliary power units. I wanted to clear up what the question was.

Mr. MCDONOUGH. Rover, yes.

Colonel ARMSTRONG. This is entirely a function of what is the payload you want to put up, and how do you want to put it there, and where do you want to put it?

Now, thrust in itself, when you are talking about chemical systems, you can sort of compare the relative merits of chemical systems by discussing the relative thrust which they will put up.

This same comparison is not true between a nuclear system and a chemical system.

The reason is this: The specific impulse of the nuclear system is at least double that of a chemical system.

Now, when you combine an increase in specific impulse with a lower weight of the entire system, then you can do the same job with less thrust than you can in a chemical system.

This is a very complicated answer to your question, I realize.

But let me put it this way: If you had a job to do that took 3 million pounds of thrust with a chemical engine, you could do that same job with less than a million pounds of thrust with a nuclear system.

Mr. MCDONOUGH. Well, now, you are speaking about using nuclear power for the propulsion instead of the chemical element for propulsion?

Colonel ARMSTRONG. Yes, sir.

Mr. MCDONOUGH. I'm asking in addition to that I am asking for this information.

If you were to propel a spaceship with nuclear power, you would have to put it into orbit?

Mr. ARMSTRONG. Yes, sir.

Mr. MCDONOUGH. How much thrust do you need—I mean chemical thrust, liquid or solid—how much thrust do you need to put a Rover unit into orbit? My impression is that it is pretty heavy. You've got to put it into orbit, then the nuclear power would be turned on navigation purposes, for traveling purposes. How much thrust do you need for that?

Colonel ARMSTRONG. I think I best answer that by quoting a specific system which NASA has in mind.

Here you would take a Saturn booster with a million and a half pounds of thrust.

You would use a second and perhaps a third stage of hydrogen-oxygen engines. Then you would put a very small nuclear rocket on top of this, and you would place that nuclear rocket as a payload, the whole thing, into orbit.

Having established that orbit, then you could turn on your nuclear system and depart from that orbit to an orbit around another planet.

Now, in this case, this entire system then calls for the Saturn booster.

There are many other applications that you could make, all the way from starting with a nuclear rocket on the ground, and that it would put a payload into orbit, to use it as a second stage on a Saturn, or second stage on an Atlas, depending on what you want to do.

Mr. MCDONOUGH. What is the time schedule or the possibility of such a firing?

Colonel ARMSTRONG. We feel if we were to get the budget which we requested for the fiscal year 1961, that we can prove the feasibility of this entire system by 1963, and that you can go directly from there, depending upon the way your program has gone, how it has been directed, and what its end result is supposed to prove, into an engineered system for flight within a relatively few years.

Mr. MCDONOUGH. Are you telling me that nothing less than the Saturn propulsion unit is necessary to put into orbit any nuclear——

Colonel ARMSTRONG. No, sir; that would be the last thing I would say.

Mr. MCDONOUGH. What is the minimum then?

Colonel ARMSTRONG. The absolute minimum is to take the testing device we are going to test in 1963, engineer that as we go along, take it out and fire it off its own tail, with a rather interesting payload, straight up, as a probe, and this could be done earlier, I feel.

Mr. MCDONOUGH. How much thrust?

Colonel ARMSTRONG. This is my personal opinion. The thrust of this device will be in the neighborhood of 52,000 pounds, the last engineering study I saw, the total system would weight about 40,000 pounds. It would carry about 1,000 pounds of payload. That is a probe, that would be the simplest first move that you could make.

Mr. MCDONOUGH. In your opinion do you think a million-and-a-half-pound-thrust engine is essential to a practical demonstration of nuclear power?

General BRANCH. No, sir; I do not.

Mr. MCDONOUGH. You don't?

Colonel ARMSTRONG. No.

One of the studies that we have looked at very carefully as perhaps the second step down the line, is to take an Atlas booster, take an actual Atlas tank and put it on the nuclear system as the second stage. It does a rather interesting job.

Mr. MCDONOUGH. So that your total weight for a practical demonstration of nuclear navigation in a spaceship would be what? What would you estimate the total to be.

Colonel ARMSTRONG. I think you posed a new problem. You have posed the problem then of going from an orbit to someplace else?

Mr. MCDONOUGH. Yes.

Colonel ARMSTRONG. Well, I'm afraid then you are back to a million and a half pounds, because you have posed a very difficult job.

Mr. MCDONOUGH. That is the reason I asked the question about the million-and-a-half-pound thrust.

Wouldn't that be the minimum amount of thrust you would need to put a navigational atomic-powered spaceship, not manned, but I mean unmanned, into orbit?

Colonel ARMSTRONG. Not in orbit, no, sir, but if you wish to put it into orbit so that that nuclear system would go from that orbit to another planet, yes, sir, the answer is a million and a half pounds.

Mr. MCDONOUGH. Nothing less than that?

Colonel ARMSTRONG. That is correct.

Mr. MCDONOUGH. And more if we can get it?

Colonel ARMSTRONG. My imagination doesn't go much beyond a million and a half pounds, sir.

Mr. MCDONOUGH. That is all, Mr. Chairman.

Mr. SISK. We are happy to have had, from time to time this morning, some of our colleagues on the full committee with us. I believe most of them are gone now. I believe Mr. Wolf is still here. Do you have any questions, Mr. Wolf, you would like to ask before we proceed with the staff people who have a couple of questions?

Mr. WOLF. I don't believe I do, Mr. Chairman. I just want to say that I am glad I was able to get down and see this operation.

Mr. MCDONOUGH. Mr. Chairman, just another question out of curiosity. What is your estimated life of this unit you have here?

General BRANCH. The Snap III polonium, this particular isotope of polonium has 138-day half-life. Every 138 days it loses about half its power. It depends, of course, on what the minimum amount of power s that you will want to use out of this thing. This thing now, for example, has gone through the equivalent of four half-lives, since it was first theoretically at full fuel. Actually we fueled it at half fuel to simulate having gone through one half-life. As you still see it is putting out useful power. If the useful power is this low, you could say 5 years, possibly.

Colonel ARMSTRONG. It depends on what isotope you want to put in it. Plutonium 238 is 86.4 years. Cerium 14.4 is 285 days and strontium 90 is 28 years. So by selecting any one of the isotopes that you wish tailored to fit the job, you can get any length of time of power that you want out of it.

Mr. SISK. Mr. Wolf?

Mr. WOLF. One question comes to mind. What would be the comparative costs of getting the same thrust from a chemically fueled engine in this case? Have you made any studies or done any research to establish this?

General BRANCH. Colonel Armstrong will answer that. I would like to say in general, though, in a normal sense, you can't compare chemical and nuclear costs if you want to do exactly the same thing with nuclear you want to do with chemical. If you want to do a better thing, and you use nuclear, then, of course, nuclear becomes competitive. It is a matter of nuclear fuel having a much longer life, and therefore being competitive in terms of usefulness against the chemical fuel.

Colonel ARMSTRONG. Of course, the major cost of a nuclear system is the uranium 235 that is in the system. I hesitate to say that the nuclear system would cost the same price, or that conversely it would cost twice as much or anything of the kind, because you have to first talk about how a big a system do you want to build, how much power do you want to pack into it, but if you were to build a nuclear device which would do the same job as a comparable chemical device—and now I'm talking about the big ones, not small ones—you are just about in the same price range, because the complexity of the nuclear device is less than that of a multistage chemical device.

As an example, a single-stage nuclear device will do approximately the same job as a three-stage chemical device. You have one pump, one tank, one reactor.

In a chemical device you have two tanks for each stage, two pumps for each stage, it is just more complex.

So right now you would say, yes, the nuclear system, because less is know about it, is more expensive. I would hesitate to say they won't come to a point where the price will be comparable.

Mr. SISK. Mr. Hines?

Mr. HINES. No questions.

Mr. SISK. Mr. Wilcove?

Mr. WILCOVE. Thank you, Mr. Chairman.

General, how soon do you feel a nuclear propulsion booster could be ready for space flight, that is, the initial booster? Do you care to give us an estimate on that?

General BRANCH. I can give you an answer. My problem is I am worried about the classification of the answer.

Mr. WILCOVE. I don't want you to violate security.

General BRANCH. I would like to talk to Colonel Armstrong a minute to be sure we are clear.

Well, if you don't mind a general answer, I would say the late sixties without any trouble. It depends how badly one wants to push this thing. If we have an urgent requirement for it we could do it in a short-time scale. The late sixties I think is a proper unclassified answer.

Mr. WILCOVE. All right.

How long before this same booster could be tied in with a space vehicle and be ready for use?

General BRANCH. I am afraid this specific answer to this question is something I am not competent to give. I think the NASA people would be in better position to give it. I would say from what I know,

though, there would be a year or two difference between, if I understand the question correctly, a year or two difference between what they want our device for and when we could get it ready at the earliest time.

Mr. WILCOVE. In other words, it would be in the sixties?

General BRANCH. Yes, sir.

Mr. WILCOVE. Is the state of the art sufficiently advanced so a nuclear-powered space vehicle could be prepared with sufficient power to land an expedition on the Moon in this decade?

General BRANCH. The state of the art in the nuclear propulsion business, specifically the Rover device, is such that we feel confident we could provide the necessary power if the vehicle were developed to use this power.

Mr. WILCOVE. Could you develop your propulsion sufficiently in time so that a vehicle could be prepared in time to land an expedition on the Moon this decade?

General BRANCH. Yes, sir.

Mr. WILCOVE. A manned expedition?

General BRANCH. Yes, sir.

Mr. WILCOVE. This doesn't call for any comment, General, but you know NASA has no schedule for a manned expedition to the Moon for this decade, apparently on the theory no chemical engine will be available for that purpose in time.

Now, left me ask you this.

Krafft Ehricke, the Convair Astronautics scientist, stated:

If the Soviet Union tried for a nuclear rocket instead of a Nova, and the United States has not, the United States may find itself falling further behind instead of catching up.

Do you agree with him?

General BRANCH. I am sorry. I am not trying to dodge the question. I would like to again refer to Colonel Armstrong, who is familiar with this particular speech and I am not.

Mr. WILCOVE. Surely.

Colonel ARMSTRONG. Krafft is probably at least as bad or worse a nuclear enthusiast as I am. I had the pleasure of having breakfast with him the day before last, and we talked about this very subject. I think the nuclear systems offer us an opportunity to take a jump over the Russians. I only hope that they are not working at it as hard as we are.

Mr. WILCOVE. In other words, the danger is present in your view, that if the Russians push ahead on this harder than we do, they may achieve a breakthrough which will put them further ahead of us than they presently are. Is that right?

Colonel ARMSTRONG. I think the first nuclear use—that the first peaceful use of nuclear energy in space is one of the big breakthroughs for which you will get as much international fame as the first satellites in space. I would like to see this one have the Stars and Stripes on it for a change.

Mr. WILCOVE. The danger at the present is that instead of catching up with the Russians, we might fall still further behind?

Mr. SISK. That answer was "Yes"?

Colonel ARMSTRONG. That answer was "Yes."

Mr. SISK. The reporter doesn't get that nod, Colonel.

Mr. McDonough. Mr. Chairman.

Mr. Sisk. The gentleman from California has one other question here.

Mr. McDonough. Is the principle of nuclear propulsion controlled the same as a controlled atomic blast?

Colonel Armstrong. No, sir.

I assume you are talking about controlled thermo-nuclear processes, or controlling a fission bomb?

Mr. McDonough. Yes.

Colonel Armstrong. No, this is not the same, in that you are not trying to achieve a prompt critical condition of the material, so that the energy release is instantaneous. You control the release of the energy by placing your material throughout what is known as a moderator. You slow down your neutrons this way, and then you place neutron-absorbing control rods into the device, so that you only withdraw them far enough to get the energy and heat that you want.

If you overdrew the control rods, you wouldn't get a bomb explosion, but the reactor would run away and melt down. So it is not a controlled blast effect, it is a controlled fission effect.

Mr. McDonough. Now, the unit to do this, from the ground up, would be heavier than the same unit with the same power using chemical propulsion, is that not so?

Colonel Armstrong. No, sir. If it were a small unit, if it were a unit to do something like the Atlas does, then, yes, the nuclear system would be much heavier. But as you go up in the difficulty of the mission, there is a crossover point at which the nuclear system becomes lighter than the chemical system. This is why less thrust is required to do the same job.

Mr. McDonough. Now, in the controlling of the fission, an increase of the propulsion, not to the point of melting the unit, is mechanically done in the unit?

Colonel Armstrong. Yes, sir.

Mr. McDonough. As it goes up?

Colonel Armstrong. Yes, sir.

This is a case where you have sensing equipment that senses the neutron flux and the temperature of the reactor, and thereby installs or withdraws the control rods as the mechanism requires. All reactors operate on this principle. The rocket reactor is no different than the power reactor in this case.

We have demonstrated that we can do this last July when we operated the Kiwi-A reactor. We ran this in Nevada. It was very successful. And the control aspects of the reactor exceeded our fondest expectations.

As you perhaps realize, as you sense the velocity of this rocket, you may wish to increase the power or decrease the power. They took the control rods and put them on a very short time constant of pushing them in and pulling them out so many times a second, and the reactor followed along just as beautifully as could be.

Mr. McDonough. Was that ground control?

Colonel Armstrong. That was controlled in the control system the same as in the reactor.

General Branch. On the ground, because it was a test device.

Colonel Armstrong. It was a test device, yes.

Mr. McDONOUGH. How large a shot was that?

Colonel ARMSTRONG. How large a reactor?

Mr. McDONOUGH. You didn't go to space on that?

Colonel ARMSTRONG. No, sir. As a matter of fact, we turned it upside down and shot the blast up in the air so it wasn't intended to be a flying device of any kind.

Mr. McDONOUGH. Do you know what your thrust was?

Colonel ARMSTRONG. Yes, sir; we do know what the thrust was. It was around in the neighborhood of 12,000 pounds, but this is a phony figure, because the nozzle that we had on it wasn't intended to demonstrate thrust, it was just a little short nozzle. Thrust didn't interest us at all in this reactor; all we were looking for was the reactor information.

Mr. McDONOUGH. If you had a nuclear thrust unit ready to operate, you have to lift a lot of weight off the ground first?

Colonel ARMSTRONG. Yes.

Mr. McDONOUGH. That is like the takeoff in a plane. You have to use all the power you've got to get up. Once you get up, you can moderate a little bit.

How do you control the heat element in the fission volume on the takeoff?

Colonel ARMSTRONG. Well, the control rods are slowly withdrawn so that you have a very low power, but you have very high heat. This is something you can do with the reactor. You can increase your temperature, but you don't have to increase your power. So you bring your reactor up to temperature very quickly, but you keep the power low. At this stage of the game, then, you increase the power on your reactor. Your pumps start up and start pumping the liquid hydrogen down through the reactor and your thrust begins. You are at full power at this stage of the game. And, like an Atlas engine, or any other engine, when she starts up, she starts up very slowly off the ground, then increases in velocity.

Now, if at some time you wanted to control this power and bring it down, because you felt that you were going too fast why, then, the control rods would be pushed back in partly, power would go down, the temperature would stay up; you would decrease the amount of hydrogen going through it, and you would decrease your power accordingly.

Mr. McDONOUGH. Am I correct in believing you get more uniform combustion of your fuel with atomic power than you would with chemicals?

Colonel ARMSTRONG. You put your finger on really what is the answer to this system. You don't have a combustion. You don't have to burn anything. You have substituted a reactor for a tank of oxygen, and you heat your hydrogen, instead of by a flame of combustion of combining the oxygen and hydrogen, you just heat the hydrogen by pushing it through the reactor. This is the answer to the system.

Mr. McDONOUGH. I see.

Then the efficiency of the atomic propulsion is much higher than the chemical?

Colonel ARMSTRONG. And the energy potential is far beyond that that you can expect as the energy potential in any chemical.

Mr. McDonough. Thank you.

Mr. Sisk. I believe that concludes the questioning, and I want to say to you General Branch, and to you, Colonel Armstrong, and Colonel Anderson, that we certainly appreciate your comments here this morning.

I feel that you are pretty definitely "sold" on the possibilities of nuclear propulsion, and I certainly appreciate it.

I have been particularly—and I might say pleasantly—surprised this morning with the apparent great amount of confidence that you do have in nuclear propulsion.

In our consideration, then, of moving ahead in our space programs, we come to the point where, as a practical matter, I think we have to admit that we are involved in some very practical problems of a space race if we are going to do things that we would like to do. On behalf of the committee we appreciate very much your statement here this morning.

Now, I understand that you are prepared to make a short statement in executive session. However, I simply want to ask you, General Branch, in view of the jurisdiction which our committee has—which of course, as far as you people are concerned, is very limited—and only from the standpoint that we want to see that NASA has and properly utilizes all the money it can in making useful application of the things that you have done in your field, if you feel the information you had that you might give us in executive session could be very useful to us in the consideration of that question.

General Branch. I think not, sir, in that what we could give in executive session would be more specific technical details on the same things we have talked about in generalities here in open session.

Mr. Sisk. I might say, then, General Branch, that it is my understanding that the chairman of the committee expects to have you people before the full committee at some later date for a somewhat broader discussion, and possibly in executive session. With that in mind, I think that we should pass up the executive session.

Mr. McDonough. Yes, I agree with you.

Mr. Sisk. With that, I express our appreciation for you gentlemen being here this morning.

Mr. Wolf. I would like to say thank you, Mr. Chairman, for inviting the members of the full committee to be present at your subcommittee.

Mr. Sisk. I believe before our committee adjourns, we have with us this morning a gentleman or two who might make some short comments on Project Orion.

Who are the gentlemen who were to be here this morning on that?

If you gentlemen would take your place at the witness stand, we would like an opportunity, briefly, to ask a few questions, and to give you an opportunity to make a short statement.

I believe it is Mr. Godel and Commander Luker, right?

Mr. Godel. That is right.

We can make a general statement, Mr. Chairman, as to the nature of Orion, similar to that which we made last year.

There is a formal briefing along with a 5-minute film which shows the progress which has been achieved in this program, which may be of more interest to you. It is, however, classified.

Mr. SISK. Let's just have a brief statement in open session, of the general purposes and matters pertaining to the finances of Project Orion and what the status of it is.

You certainly will protect any security matters and not discuss any of those things which have to do with security. Then we will move into executive session later.

I happen to be one of these people who believe we should make everything public that we can. After all, we are conducting the public's business. I know you people appreciate that. I certainly do not criticize the fact that we must protect our national security, and because of that we have to protect these things in executive session.

Could you make a general statement? I have in mind primarily what the situation is as to the immediate future regarding your financing or funding problem. This is basically, of course, where we would be concerned. If there is something that we, as an authorizing committee, from a standpoint of money, might be able to do for you in your program and if it could be justified, we would be glad to do it.

STATEMENT OF WILLIAM H. GODEL, DIVISION OF PROJECTS AND PLANNING, ARPA

Mr. GODEL. All right, sir.

Project Orion has been previously announced as a completely different concept of achieving propulsion by the use of nuclear power than that which you have heard thus far this morning.

In a perhaps oversimplified description, it is the concept of dropping a series of explosive devices, nuclear explosive devices, behind a very heavy space vehicle and through the means of a "bumper," literally bumping that vehicle into space.

Its attractiveness, from the point of view of the Department of Defense, has been one of a least theoretically enabling the Nation to put extremely heavy space vehicles, in the hundreds of tons category, into space, if indeed the technical problems can be worked out.

The program was conceived largely within the General Dynamics Corp. 2 years ago. It was funded by the Advanced Research Projects Agency on a study contract and feasibility demonstration basis in the amount of about $2.4 million.

As a part of the overall decision, relating to the establishment of the National Aeronautics and Space Administration and the transfer of space projects from ARPA to other agencies, either the action agencies of the Department of Defense, the three services, or to NASA, this project is one of those that is programed for transfer from the Advanced Research Projects Agency to elsewhere.

As you are aware, Dr. York suggested to the Director of NASA that that agency might wish to assume responsibility for further development of this program. The Director of NASA, for a number of reasons, which I am sure he would be pleased to talk to you about, has felt his agency cannot assume this responsibility at this time.

Accordingly, we now propose, and are in the preparation of correspondence which will transfer this program, its continuation at least, in fiscal year 1961, to the Department of the Air Force.

As to its funding, it is currently being funded at the rate of $100,000 a month. From a purely technical point of view, it would be perhaps possible to proceed with the program at a somewhat more rapid rate. We in the Department of Defense made the decision last year not to proceed at a more rapid rate because proceeding at a more

rapid rate would entail testing, utilizing nuclear explosions. In the light of the current moratorium on nuclear explosions, it didn't seem—one couldn't, in fact, proceed with the technical feasibility demonstration at the rate that might technically be possible.

Accordingly, it is our present view that the program, if it is to be continued, should be continued on the basis of maintaining that minimum rate, that minimum capability which is consistent with the political circumstances and the moratorium circumstances that now attain.

This would then in fact amount to approximately $100,000 a month.

Mr. SISK. Let me ask you a question with regard to your personal opinion, Mr. Godel, and I hope you will feel free to express your honest conviction.

Is this a program that you feel should be transferred to NASA? Because of its prime responsibility in the field of space and in launching large loads into space, do you personally have a feeling that this is a project that should be in NASA?

Mr. GODEL. Sir, I can't give you a completely unambiguous answer. I will have to explain, I should think, a little bit.

This is one of those projects that is, as I think Mr. Johnson testified last year, very "blue sky" indeed.

There are a great number of both political and technical problems that require to be solved. This is not a program which can reasonably be expected to provide useful thrust in a short time period in the sense of, well, even comparing it for example to the Saturn program.

I believe it is in the sense that space exploration is a function of the National Aeronautics and Space Administration, I would suppose that I, for one, would think that this is worth pursuing as a long-term, very advanced research project.

In the sense, however, that possible military systems employing, if I can be mildly facetious, battleship-type size, vehicles in the far distant future, may very well be of interest to the Department of Defense. I would suppose this is one of these things that is in a very "gray" area. In the light of the priorities that currently obtain to NASA, and its activities, I would think this can quite as reasonably be performed within the Department of Defense, as long as it is in the exploratory research stage, certainly.

Mr. SISK. Does the gentleman from California have some questions?

Is that generally just about all you want to touch on in open session? Is that right?

Mr. GODEL. There is no particular classification—there is none, of course, in what we have said today. If you want to talk about the technical details of the program, in detail, I would prefer to go into executive session.

Mr. SISK. I think we will proceed with such questions as the committee has at this time.

Mr. MCDONOUGH. I will reserve my time.

Mr. ROUSH. I have no questions.

Mr. SISK. The gentleman from New Mexico?

Mr. MORRIS. I have no questions.

Mr. SISK. Mr. Wilcove?

Mr. WILCOVE. Mr. Godel, my understanding of the program is that at the present time you have a feasibility study contract with a company in San Diego, which will run through August of this year. Is that correct?

Mr. GODEL. That is correct.

Mr. WILCOVE. If further funds are not made available, then the project will terminate at that time. Is that correct?

Mr. GODEL. Yes, sir.

Mr. WILCOVE. Now, I understand that further consideration has now been given to transfer of the project to the Air Force, but no final decision has been made on that?

Mr. GODEL. I think the decision has been made to present it to the Air Force; yes, sir. The correspondence has not physically been forwarded; no, sir.

Mr. WILCOVE. Will the Air Force be given any additional funds?

Mr. GODEL. To the extent the program is to be continued, there would not be, as I understand it, additional funds provided within the Air Force budget; no, sir. There are no further funds beyond August currently budgeted. However, I understand the Air Force has, by reprograming authority, or at least it expects by reprograming authority, if it assumes the program, to continue the funding.

Mr. WILCOVE. From my previous conversation with you, it is my understanding there are some people in the Air Force who feel that this theory, and so far it is only a theory, can be proven possibly by the use of high explosives, rather than nuclear probes?

Mr. GODEL. If I gave you that impression, sir, and I will defer that to Commander Luker in a moment, who is the expert on it, I would want to correct it.

There are components, such as the ablation characteristics of the bumper which can be so demonstrated, but not the entire theory; no, sir.

Mr. WILCOVE. Not the entire theory, but at least part of it, the concept of it?

Mr. GODEL. Yes, sir.

Mr. WILCOVE. That would cost roughly $1 million to $1.9 million to carry it forward for another year?

Mr. GODEL. Yes, sir; in that order of magnitude; something like this, perhaps a little less.

Mr. WILCOVE. So $1 or $2 million would be needed, if I may sum it up this way, to possibly prove the feasibility of this concept?

Mr. GODEL. No, sir; again I would wish to limit the statement to: this kind of money or any kind of money in the next year, employing these devices, would only prove certain critical components of the entire theory, or of the entire system.

Mr. WILCOVE. Mr. Chairman, just one other thing. If it is satisfactory with the chairman and the subcommittee, I would like to place in the record a letter from Dr. Herbert York to Dr. Glennan, Administrator of NASA, and the response to Dr. York, signed by Richard Horner, the Associate Director of NASA.

Mr. ROUSH (presiding). We will place these in the record.

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING,
Washington, D.C.

Hon. T. KEITH GLENNAN,
Administrator, National Aeronautics and Space Administration.

DEAR DR. GLENNAN: The purpose of this letter is to request your comments on the transfer of the Orion feasibility study to your cognizance in conformity with the DOD/NASA memorandum agreement, dated October 21, 1959. I understand you and your staff have been briefed on the latest status of the program, and that a meeting has been held with Dr. Finger of your staff on the subject of transfer.

Of major concern is the future funding level, which presently has not been established within the DOD, but which may indicate a somewhat higher level of effort.

About $900,000 of supplemental funding for fiscal year 1960 was being considered; however, ARPA does not have resources to carry this increased level. In the event of transfer of the study to your cognizance, only the currently obligated funds would be available.

I would appreciate your comments on this transfer.

Sincerely yours,

HERBERT F. YORK.

FEBRUARY 10, 1960.

DR. HERBERT F. YORK,
Director of Defense Research and Engineering, Department of Defense, Washington, D.C.

DEAR DR. YORK: This is in reply to your letter of January 29 concerning the cognizance of the Orion feasibility study. We have carefully considered the factors which bear on this question and have come to the conclusion that the NASA should not undertake this responsibility.

Although the Orion propulsion device embraces a very interesting theoretical concept, it appears to suffer from such major research and development problems that it would not successfully compete for support in the context of our entire space experimentation program. Among other uncertainties, the question of political approval for ever using such a device seems to weigh heavily in the balance against it.

As you probably know, we have made extensive commitments in the financial resources that we have requested for fiscal year 1961 and it would be extremely difficult to divert funds from nearer term projects for the support of Orion. We would not, therefore, favor any arrangement requiring such support.

Sincerely yours,

RICHARD E. HORNER, *Associate Administrator.*

Mr. ROUSH. Mr. Hines?

Mr. HINES. Can you tell us how much money has been spent to date?

Commander LUKER. $2,440,008.

Mr. HINES. When was the date of the first appropriation?

Commander LUKER. July 1958.

Mr. HINES. Who are the principal contractors?

Commander LUKER. There is really only one. The contractor is General Atomic, a division of General Dynamics.

Mr. HINES. Are there any other contractors involved?

Commander LUKER. In its present status as a feasibility study, there would be no point in having any other contractors in this particular concept. There might be competitive concepts, but in this particular one, I would think there would be no point to have another contractor.

Mr. HINES. Thank you.

Mr. ROUSH. Are there any other questions while we are in open session?

Mr. WILCOVE. One thing I did want to bring out further.

I understand Dr. Stanislaus Ulam, a scientist at the Los Alamos Scientific Laboratory, who has come to be considered one of the fathers of the hydrogen bomb, told the Joint Atomic Energy Committee last week that he considered this concept feasible, and in the event of a breakthrough it would be as important or more important than the development of the atomic bomb.

I am not a scientist, but what do you gentlemen think about that?

Commander LUKER. Well, it depends on your degree of confidence in the success of this thing. If in fact it were a workable system, which we certainly cannot say today, but if it were, it would be a major breakthrough of an order of magnitude that, well, I think it would be a major step forward, certainly. We could use space much as we use the air around the earth now. This is a big "if," I want to emphasize, though. This is certainly not a fait accompli.

Mr. WILCOVE. You are the project officer, are you not, on Orion?

Commander LUKER. Yes, sir.

Mr. WILCOVE. Is it your personal opinion this project should be continued?

Commander LUKER. Yes, sir.

Mr. WILCOVE. You think it is urgent to continue it?

Commander LUKER. Yes, sir.

Mr. WILCOVE. Thank you.

Mr. ROUSH. Are there any other questions?

Now, do I understand, Mr. Godel, that you have a brief or a short film which should be presented in executive session?

Mr. GODEL. That is correct, sir.

Mr. ROUSH. How long will this take?

Mr. GODEL. The film is 5 minutes. There is perhaps 3 to 4 to 5 minutes of conversation to go with it. It is a silent film, sir.

Mr. ROUSH. All right, the committee will go into executive session.

(Whereupon, at 11:57 a.m., the subcommittee procedeed in executive session.)

[EXECUTIVE SESSION]

1961 NASA AUTHORIZATION

FRIDAY, FEBRUARY 26, 1960

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE NO. 4,
Washington, D.C.

The subcommittee met at 11:57 a.m., Hon. J. Edward Roush presiding.

Mr. ROUSH. Are we all cleared?

All right, you may proceed with the film.

STATEMENTS OF COMDR. ROBERT LUKER, PROJECTS OFFICER, ARPA; AND WILLIAM H. GODEL, DIVISION OF PROJECTS AND PLANNING, ARPA—Continued

Commander LUKER. If I may, Mr. Sisk, I would like to preface the film with a few remarks.

Mr. MCDONOUGH. Correct that to Mr. Roush.

Mr. ROUSH. I am just acting as chairman.

Commander LUKER. Oh, I beg your pardon.

The general concept has already been explained. The classified part of the program is the way in which the propulsion is actually achieved. * * *

and this is also a problem which is insurmountable under a moratorium, at least one which does not differentiate between such a propulsive device and a bomb.

It is a nuclear explosion, and if a moratorium bans a nuclear explosion, the device can never be tested. * * *

This is fairly well demonstrated.

However, in putting this type of a vehicle in orbit,

* * * * * * *

I must point out we cannot prove this.

* * * * * * *

I believe that is all that is necessary. I might make a few comments as the film is run.

This is a 3-foot diameter model which weighs approximately 300 pounds [showing film].

It has a ballistic shaped envelope, as would an Orion vehicle, only for travel through the atmosphere to reduce drag.

(Indicating film.)

Commander LUKER.

* * * * * * *

These are slow motion shots. The vehicle, this model is completely untethered in free flight. This is one without the ballistic envelope.

(Film concluded.)

Mr. GODEL. You might explain, Bob, what the occasion of this particular experiment was.

Commander LUKER. Actually, this model does not in any way bear on the real problem of propelling a ship with a nuclear detonation.

These are small 3-pound "HE" charges, and it has been put together at the contractor's expense. As a matter of fact the films that were just shown were not done of Government expense, to show that such a concept, that is, propulsion by detonation, is, in fact, feasible.

Actually, the efficiency of this propulsion system, even with "HE," *is reasonably good in the* atmosphere, where the oxidizer is not carried along, but uses the air. High explosives could not be used this way at very high altitude.

Mr. ROUSH. Mr. Morris, do you have questions?

Mr. MORRIS. What do you mean, what type of explosives?

Commander LUKER. In this particular case it is just the common TNT.

Mr. ROUSH. That is what you used in this model?

Commander LUKER. Yes.

Mr. MORRIS. But you can't use that at high altitude, can you?

Commander LUKER. No, that was my point. This is sufficient in the atmosphere only because the oxidizer is not carried along as it is in a rocket. No oxygen is necessary. It just uses the air.

Mr. MORRIS. Is that what you call Project Put Put?

Commander LUKER. That is a name given to it by some people. That is correct.

Mr. ROUSH. Mr. McDonough?

Mr. MCDONOUGH. You never attempted to make an experiment with a small atomic bomb?

Commander LUKER. No, sir. On the prospects of a moratorium which does not differentiate between such kinds of devices and a bomb, as in the current concept, this could never be tested, nor flown.

Mr. GODEL. In the atmosphere, of course, you have all the attendant problems, Mr. McDonough, of fallout, radiation hazards and so forth that were touched on this morning.

These are sort of the overwhelming political difficulties in the way of this project.

Mr. MCDONOUGH. That is all.

Mr. ROUSH. Mr. Wilcove?

Mr. WILCOVE. I have a few questions. I believe it has been stated that if this theory is found to be feasible, you could put as much as 20 million pounds in space?

Commander LUKER. There is no conceivable upper limit. That is, the upper limit gets to be such that you are talking about something the size of the Pentagon.

Mr. WILCOVE. The theory is you could put something the size of the Pentagon into space with this?

Commander LUKER. Yes. * * *

Mr. MCDONOUGH. Your problem there would be your structure?

Commander LUKER. Structure is the only limit.

Mr. MCDONOUGH. Structure to put this object on top of it?

Commander LUKER. A thing to hold together at the upper limit. This has been computed very roughly by the contractor as a mathematical game to be roughly 29 million tons.

Mr. WILCOVE. How many shots would you need to put a vehicle into the air sufficient to take a manned expedition to the Moon?

Commander LUKER. Several hundred. Well, this is such an order of magnitude different than we are thinking of in terms of chemical or heat exchanger type of rocket propulsion, using nuclear energy, the Orion concept provides for a specific impulse which can be an order of magnitude 10 times that of chemical, and it has a thrust-to-weight ratio which is considerably better than a chemical system. And it is also a good many times better than could be achieved by a Rover type.

Mr. GODEL. Yes, but isn't there a crossover point, Bob? This is really only attractive if you are talking about exceedingly heavy objects? It isn't as attractive—it is not attractive at all if one thinks in terms of the Atlas type mission or even the Saturn type mission?

Commander LUKER. No, certainly, but for man.

Mr. GODEL. For men, depending on how many men.

Mr. WILCOVE. Let's assume you send one or two people along.

Commander LUKER. I think I can answer that fairly graphically.

We have an engineering design feasibility study going on this year. * * *

* * * and it would be capable of putting 200 tons into space as compared to what Saturn will be able to do.

Mr. WILCOVE. 200 tons?

Commander LUKER. * * *

Mr. WILCOVE. It wouldn't be much of a task for this method, provided you have a working program to put a man on the moon, would it?

Commander LUKER. No, it would not. However, it would contaminate the moon using the present nuclear charges. At least, the scientists would insist on putting an Orion vehicle in moon orbit, and then coming out of orbit in a chemical booster.

Mr. WILCOVE. Is there any thought by the sponsors of this project that possibly some time in the future it will be possible to use nuclear explosives in such a way it will not contaminate the atmosphere?

Mr. GODEL. This entails a development of a completely clean bomb, sir, and that is another development program, but would also fall within the moratorium.

Mr. WILCOVE. I appreciate that.

Commander LUKER. * * * and it is not an actuality.

Mr. WILCOVE. Well, neither is the other one. Thank you.

Mr. ROUSH. Mr. Hines?

Mr. HINES. No questions.

Mr. ROUSH. Mr. Wilcove, do we meet at 2 o'clock this afternoon?

Mr. WILCOVE. Yes.

Mr. ROUSH. If you gentlemen have nothing else to present then, we thank you for appearing before the subcommittee.

Mr. McDonough. One further question.

This is in a proposal stage?

Mr. Godel. It is in a feasibility study, sir. We will have expended by the end of August, $2.4 million in demonstrating, doing the theoretical feasibility studies on the program.

Mr. McDonough. But you use the fission propulsion here instead of the explosion. Would that remove your radiation problem if you did that?

Mr. Godel. No, sir. These are two completely separate methods of attacking the problem. The thing General Branch and others talked about this morning are a way of utilizing nuclear energy to achieve propulsion, but this does depend on the explosive force.

Mr. McDonough. That is all.

Mr. Wilcove. Wasn't Dr. Taylor of the AEC Scientific Laboratory at Los Alamos working on this project before he left AEC?

Commander Luker. I am afraid I can't answer that. He did not propose it or officially work on it until after he had left the AEC.

Mr. Wilcove. He is working on it now, though, is he not?

Commander Luker. He is the No. 1 scientist on the team, at General Atomic, yes.

Mr. Wilcove. I have heard he thought so highly of this project that is one of the major reasons he left AEC to join General Atomic, to work on this project.

Commander Luker. I am afraid I can't answer that, sir.

Mr. Roush. I thank you for appearing before us, gentlemen.

The committee will stand in recess until 2 o'clock this afternoon.

(Whereupon, at 12:15 p.m., the committee recessed to reconvene at 2 p.m., the same day.)

[OPEN SESSION]

AFTERNOON SESSION

Mr. Sisk. The committee will come to order, for the further consideration of our portion of the budget.

Off the record.

(Discussion off the record.)

Mr. Sisk. We have completed action on all sections over which the Subcommittee No. 4 has jurisdiction, with the exception of that portion dealing with nuclear systems technology. I believe we still have to take final action on approving the nuclear and the liquid rocket section.

Due to certain considerations and the interest of the committee in the progress of the nuclear propulsion devices that might be available, and their possible application to space flight, we felt that we wanted to hear the AEC people this morning, which we did. Now, Dr. Dryden, we are very happy to have you here before us today, along with Mr. Finger. Mr. Finger has been with us from time to time recently. We are glad to have you back, Mr. Finger, to discuss this particular portion of our budget.

Mr. Finger, were you here this morning during the discussion with General Branch and Colonel Armstrong?

Mr. Finger. Yes, I was.

Mr. SISK. I would like, unless there is objection from the committee, to have Mr. Finger give us a statement on behalf of NASA, as to his impressions of this morning's testimony. There was no implied criticism on my part this morning of NASA. I simply wished to develop the facts as clearly as possible with reference to what was being done in this field and in what ways, if possible, nuclear propulsion might move us faster ahead.

Dr. Dryden, I think we should have you say something first and make your comments, and then I would like to have Mr. Finger make comments later.

STATEMENT OF HUGH L. DRYDEN, DEPUTY ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. DRYDEN. I have not prepared any formal written statement for you, Mr. Chairman.

I would like to say that we in NASA are convinced by calculations which have been made of the very great potential of nuclear propulsion in the space field, particularly in the more difficult missions. By more difficult missions, we mean either very large weights or very long distances, or, more specifically, a combination of both.

The present situation of the project is this:

We have submitted to the AEC certain general requirements as to the size of reactor which we think useful in the upper stages of space vehicles, where nuclear power pays off more than in the first stage itself.

The AEC, as you know, has the responsibility for demonstrating what is called the "breadboard" engine.

A "breadboard engine" is an engine that has all the pieces in it that are required in a flight engine. It is an engine in which the parts are not arranged in the way they must be to be accommodated in the small space available in a rocket vehicle. The parts in a breadboard engine do not necessarily have to comply with the requirement for very low weight that must be met for use in a final flight vehicle.

The AEC has a test program, whose details are classified, which begins with pieces of the system. After being tested alone, these pieces are put together gradually in a succession of ground tests. In the course of these tests AEC does certain experimentation on materials as well. This program will lead to the demonstration of a breadboard engine.

I don't know whether the timetable was given this morning or not. A full discussion of this program, of course, could only be held in a closed session, as you gentlemen realize.

Now, during this phase, through the breadboard engine, the AEC has the leading role, so to speak, and NASA is supplying the support. For example, the pump for pumping liquid hydrogen was developed with funds provided to AEC by NASA; NASA has provided a liquid-hydrogen plant on the west coast which will supply all the fuel used by the AEC. In the Rover program we are doing work in connection with the nozzle design. And there are other pieces of support equipment for which NASA has responsibility.

We have financed in 1960 and 1961 all of the funds which are called for in the programs. Details of the program are worked out by a

coordinating committee constituted of members from the Los Alamos Laboratory, the AEC, and NASA.

I don't want to give you the impression that the program is carried to a certain point with AEC having major responsibility, and that all of a sudden this responsibility ceases and NASA becomes responsible for contracting for the development of a flight-test engine and a vehicle. The periods overlap. The AEC's major responsibility is the reactor development, and the demonstration of a breadboard engine. It is our responsibility to provide for the development of the flight engine, of the flight testing.

We have begun already the first steps in this process. We see some problems in putting the engine together. One of the problems is the effect of radiation fields on materials at the low temperatures associated with liquid hydrogen. We have undertaken some work in this area ourselves, and contracted for some more. We are studying the question, together with AEC, of what the first flight test should be.

There are differences of opinion between people within our staff. Individuals have different opinions. There are individuals within the AEC who have different opinions and different concepts of what the first flight test should be. There is no agency-to-agency difference. There are simply differences among the experts in both agencies, and we are making studies to try to decide what flight test should be contracted for and started very early.

We have written to the Budget Bureau expressing our support of Rover, and stating that we feel that this program should advance just as rapidly as the technological problems will permit.

The one thing that we have not done is to state that this engine, whose shape and weight we don't yet know, is suitable for a particular mission 7 or 8 years from now. We have said we think the Saturn is probably the first lower-stage which would enable us to put a nuclear rocket in orbit, for the first orbital tests of a nuclear rocket. We do not think, however, that the progress on the engine should be geared to the Saturn schedule. We think the engine should be moved ahead just as rapidly as possible.

As the weight of the engine and its probable size and shape become clearer, we will begin the necessary work on the design of the vehicles to use the engine, and we will take the steps to make the decision on what the first mission would be.

Even in Saturn, with a nuclear upper stage, we get a considerable increase in the load that would be carried—two or three times on a lunar mission, for example, and more than this on a deep-space mission, as compared with a chemically fueled upper stage.

However, this does not constitute what is called "optimized" use of the nuclear engine. Just as we are now in the process of developing more optimum vehicles using Atlas as first stage, it will be necessary to do further work on the optimization of vehicles to use nuclear propulsion.

With this preliminary statement you might want Mr. Finger to detail a little more closely what it is that we are doing and have underway now.

Mr. SISK. Dr. Dryden, I think that is a very good statement, and I think it indicates you are very definitely interested in moving ahead with this program.

If you would, then, Mr. Finger, comment along whatever line you would like, I would like for you to keep in mind, and touch on them in such ways as you desire, some of the statements that General Branch and Colonel Armstrong made this morning. I imagine that a little bit later we may have a few questions about what is being done with some of the actual developments they indicated are available right now.

So, if you will proceed, Mr. Finger, we will be glad to hear you.

Mr. FINGER. Thank you, Mr. Chairman.

STATEMENT OF HAROLD B. FINGER, CHIEF, NUCLEAR PROPULSION, OFFICE OF LAUNCH VEHICLE PROGRAMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. FINGER. To start with, I think that in many respects General Branch could have been testifying for NASA with exactly the same wording as he used with AEC, certainly from the point of view of having expressed NASA's point of view as well as AEC's.

Specifically, General Branch and Colonel Armstrong discussed the time phasing of various nuclear rocket applications.

Colonel Armstrong pointed out that the earliest applications of nuclear systems will certainly be in the combination of nuclear and chemical rocket systems.

The early nuclear system developments don't preclude the use of chemical systems. In fact, we will use chemical boosters to boost these nuclear systems, using the nuclear rocket as a second or a third stage, or possibly an orbital stage.

Later on, as we go down the road of development, we will gradually move the nuclear rocket stage down in the rocket. In other words, we might start out with a nuclear stage as a third stage, on top of two chemical stages, and as we go down the development road, it may become a second stage, and possibly far down the road there is the application of a first-stage system. Although by that time we should have such large chemical boosters that there is a question of what we gain by going to the extremely large nuclear ground takeoff systems.

The reason this time scale comes up in this order is that as we bring the nuclear rocket down from the third to the second to the first stage, the thermal power of the reactor goes up. For example, in an orbital stage, even on top of a Nova-type vehicle, we could get by with a nuclear orbital stage having a reactor power of 1,000 to 2,000 megawatts. If we come down, to use this as a second stage, then we start talking of the 5,000- to 10,000-megawatt range. And if we use it eventually as a large ground takeoff booster, we are talking of anywhere from 10,000 megawatts on up to 40,000 and 50,000, depending on how large we want to go.

The other problem is that as we increase power, we can't just let the reactor grow, because the weight goes up too much. So we must try to get higher power out of the same size reactor, and this is a very difficult engineering job. It involves fundamental limitations of materials, both from a temperature point of view and the stress point of view; that is, the stress at a given temperature is limited.

So we have been approaching this problem, as you know, first from the point of view of using nuclear stages as upper stages, top stages of chemical systems, and using it for interplanetary missions—really long-range missions. This is where it pays off.

Our program that we have laid out here is aimed, as Dr. Dryden mentioned, at the support of the AEC reactor program, which also is directed toward these top-stage interplanetary missions at the present time.

In addition to this reactor support program, we are doing preliminary work in developing the technology we will need on the flight test systems, and we have agreed with the AEC that we must plan an active flight test program for the nuclear rocket to determine its operation in the peculiar space environment.

First, let me discuss the support program. It is listed here in our budget request, if I may go directly into our budget——

Mr. SISK. Go right ahead.

Mr. FINGER. I would like to refer to these line items that indicate the nuclear rocket funding we are talking about.

On page 179, the very first item under nuclear heat transfer rockets is directed at this reactor test (Rover) support budget.

In fiscal year 1961 we are requesting $4.3 million in this line item.

These funds will be used to continue the development of a liquid-hydrogen pump which is required to pump hydrogen from the storage tank into the reactor where the hydrogen is heated up to produce a high-temperature gas that gives us the thrust we want.

This pump has been under development at the Rocketdyne Division of North American for almost 2 years. I should say that the technical results are very gratifying. In fact, they are so gratifying that changes and advances can be made in the reactor program as a result of this pump development.

This pump development will continue then in fiscal year 1961.

It will be used in the reactor test program.

In addition to the pump, we are developing a turbine to drive this pump. Initial tests of reactors may use an electric motor to drive the pump, but down the road we want to use a turbine to drive the pump. This turbine would be driven by hot hydrogen gas, generated either within the reactor or within the cooled jet nozzle.

Another item covered by this $4.3 million is the development of a liquid hydrogen-cooled nozzle, which is essential to the reactor test program. It is also essential to a successful flight test engine and a successful operational engine.

The fact is that the state of the art of liquid hydrogen-cooled nozzle technology is not now advanced to the point that it can satisfy all the requirements for a nuclear rocket system.

This development, then, will be an advance in state of art even over the hydrogen-oxygen chemical rocket systems. The amount of heat that has to be removed is much greater in these nuclear rocket nozzles than in hydrogen-oxygen engine nozzles.

In addition, as Dr. Dryden mentioned, in this budget item are funds for supply of liquid hydrogen, not only to the reactor test program but to all nuclear rocket test programs, including the pump development, the turbine development, nozzle development, and so on.

Following this, we are, as I mentioned and as Dr. Dryden mentioned, doing technological work on the flight system.

This work is covered by the applied research on nuclear rockets item, the second item on page 179.

Included here is a continuation of the radiation effects program. By that time, fiscal 1961, we hope to be operating the radiation test loop in the NASA-Plumbrook test reactor.

This money, then, includes contract operating money, to operate the loop in our reactor.

Also included here is work on design analysis and experiments of automatic control systems. Obviously, in these nuclear rocket systems we can't start the reactor up manually from the ground and operate it manually from the ground as we do in a tiedown ground reactor test. The system must operate automatically and control itself automatically. This requires that a system that controls the pump and turbine and the entire flow system as well as the reactor must be combined into a single, integrated, automatic control system.

Funds in this item, then cover that kind of a research effort.

The final item is listed as breadboard engine design. It isn't specifically that. It actually is design analysis of nuclear rocket systems, mission capabilities, and so on, which will be fed into the breadboard engine design, so that the breadboard engine that the AEC tests will more directly lead to a useful application than it wuold if we didn't have these early design study data.

This total, in nuclear rockets, is $5.5 million in fiscal year 1961, and it does cover all the items that are required for the support of the reactor test program as specified by the AEC.

Mr. SISK. Do you wish to go ahead with the balance of that section on the electric power generating system now, or would you rather go back and discuss this other section in the form of some questions first?

Mr. FINGER. This morning you also heard discussion on the Snap systems, in which we are very much interested.

Almost a year ago we specified to the AEC a requirement for a 30-electrical kilowatt, nuclear electric generating system. It would use a reactor almost the same as the one that was shown here this morning. You saw a model of the Snap 2 reactor.

The Snap 8 system is this 30-kilowatt, nuclear-electric generating system.

The AEC is responsible for development of the reactor, the reactor controls, and the nuclear radiation shielding that are required in the system.

The NASA is responsible for the system that converts this heat output of the reactor to electrical power output.

You saw the Snap II turbogenerator system here this morning. It is a very compact unit. The NASA is responsible for developing that equivalent system for the Snap VIII nuclear-electric program.

For that development, we have requested $2 million in 1961.

In addition, we have follow-on work on applied research on high-power systems, and Colonel Anderson commented briefly on that this morning.

We find that if we want to generate high powers using nuclear-electric systems in lightweight units, we must operate at very high temperatures. Our working fluids are liquid metals, metal bakers, and there just isn't technology developed on these fluids at high temperatures. This program is named developing the technology necessary to

permit us to go on to the development of systems of significantly higher power than the 30-kilowatt Snap VIII. We are talking about powers on the order of several hundred kilowatts and into the millions of watts, megawatts.

For that applied research, we are requesting $2.5 million in 1961, giving a total of $4.5 for nuclear-electric systems, and $10 million for the total nuclear program.

I should mention this budget item, this nuclear systems technology budget covers all of the NASA support and development in the nuclear systems area.

Thank you.

Mr. SISK. While we are on this particular section of the budget, Mr. Finger, you heard General Branch speak about this development this morning. You can correct me if I do not use the correct terminology, because you are much more familiar with the various terms he was using this morning than I am. He was talking about the marriage, as I understood, of the reactor and of the generator——

Mr. FINGER. That is correct. The turbogenerator.

Mr. SISK. And that they were ready for this marriage.

Now, is there any money in your Snap VIII development program here to consummate this marriage?

Mr. FINGER. Yes. I should first point out that the discussion this morning was directed at the Snap II development. This is a 3-kilowatt electric power output system, and falls entirely within the purview of the AEC. The development was started several years ago under joint AEC-Air Force requirements and interests.

In the Snap VIII system, the NASA is responsible for development of the turbogenerator system, and is also responsible for putting the two together, for marrying the reactor and the turbogenerator system. These funds are covered by this budget item.

It is obvious that when we get to marrying these two, there must be a very closely coordinated program between the AEC and NASA and our contractors. These full system tests will be run in the AEC facilities. The AEC is developing the reactor at Atomics International, and Atomics International is operating facilities at Santa Susanna to be used to marry these two units.

The work therefore will be done in the AEC facilities and the tests in these facilities will be under the direction of the AEC.

However, the requirements for the system, the performance specifications, are all made by NASA. The funds are here in this budget to cover this work.

Mr. SISK. Does the gentleman from Indiana have any questions?

Mr. ROUSH. I hope I am wrong on this, but I have the impression that NASA is waiting on the AEC and the AEC is waiting on NASA in the development of these programs.

The reason I have that impression is this: Dr. Dryden, a few moments ago, stated that Project Rover should advance as fast as technological problems would permit, and that when the weight factor becomes determined, you will be able to start on the vehicle.

This morning I thought I understood General Branch to say that AEC, in turn, was waiting for NASA to provide the requirement, that AEC would be able to fulfill that requirement as quickly as it

became available, and that AEC could go much faster with its program as soon as that requirement is provided.

Where am I faulty in my thinking, if I am faulty?

Dr. DRYDEN. I think if there is any difference, it is only in how detailed the requirement must be.

We have given the AEC a requirement.

Mr. FINGER. I believe that General Branch was actually talking more about the follow-on program to the breadboard engine, the vehicle development program, than he was the program up to the breadboard engine.

It is my impression, gained by quite close contact with the AEC people on the program, that there is not a great deal that can be done to accelerate the reactor research program that is now in process. The research program that will specify for us what temperatures we can get, what weight of reactor we will have; this program is set by technical pacing.

Mr. ROUSH. But, Mr. Finger, General Branch did say they could go much faster, did he not, if they were given the requirements?

Mr. FINGER. Yes, I believe he indicated that.

I don't know, I believe that he was talking about a specific mission requirement, and in that regard your point is probably well taken. We do not feel we are in a position to say we will fly a nuclear rocket on a particular mission requiring a particular payload because we don't know at this time that the nuclear rocket will indeed be able to satisfy the requirements of long-range interplanetary missions that we might specify. We don't know the possible missions at this point.

Mr. ROUSH. I assume then you don't share their same confidence and enthusiasm?

Dr. DRYDEN. This, I think, Mr. Roush, is not the point. It is the problem of, How would you design an airplane for an engine if you didn't know anything about the engine other than the general principles on which it worked?

Mr. ROUSH. I gathered from what they were saying is that if NASA would tell us what type of vehicle it is going to provide us, we will provide a nuclear propulsion system or reactor which will fit it.

That is the impression I had this morning.

Dr. DRYDEN. We have given them the power of the reactor that we want, and the requirement that it be as light as they can possibly make it.

This is the detail in which we have given the specification. We have not specified that it has to be 2 feet in diameter, or said that we won't fly it if it doesn't weigh less than a certain number of pounds. We have told them what power is desired in the reactor, and the requirement that it be just as light as it can possibly be made.

As far as its shape and dimensions are concerned, these are things that can be taken account of in the vehicle. But I think you have exactly the same problem that existed in the very early days of Aircraft Nuclear Propulsion: Some people wanted to design an airplane before they knew anything at all about the external shape and size of the engine that was going to power it. It is just impossible to get details at the current state of the technical development of nuclear

rockets, where only one component of the rocket engine has been so far tested under certain specified conditions.

As I say, I can't go into details.

Mr. SISK. Doctor, if it becomes necessary to give some of this detail in executive session, we will go into executive session. We hope to wrap up and get through with this part of our budget this afternoon, but I don't want to put you on the borderline of any security information.

Dr. DRYDEN. The situation with the F–1 engine, where only a chamber has been tested, is comparable. That is quite a ways from an engine. It was tested without the necessary pumps and other essential gadgetry that go with it.

This is the same place we are in nuclear rockets. We have a program outlined that will lead to the breadboard engine. We start with one piece, we then add another piece and another piece until we have a complete breadboard engine, and until we have some idea of weights and sizes, we can't go ahead and design a vehicle to be powered by it.

Mr. ROUSH. If AEC people were able to provide you with an engine which would meet the requirements of a manned flight to the moon, and do so within this decade, could you provide them with the vehicle to carry that engine and the payload? They said this morning that they could do that, that they could provide that engine. All they needed was the vehicle.

Dr. DRYDEN. Well, the question of a manned flight to the moon involves a great deal of technology more than the thrust power of a rocket. If I may use again the analogy of the X–15 airplane, the engine that is in that airplane will take the airplane to a much higher altitude than we know how to get back safely from.

The problems of landing on the Moon with a nuclear engine involve far more than this. You have had our estimates of when the technology would permit landing on the Moon with any kind of an engine. There are many other problems relating to guidance, to the matter of the way in which you get back from the Moon, how you reenter the Earth's atmosphere—the most critical problem in returning even an unmanned vehicle from the Moon that we have not yet solved is how to come back in the Earth's atmosphere from the Moon-Earth trajectory without burning up. The analyses of this problem show that you must hit the outer edge of the Earth's atmosphere tangentially with an accuracy of a very few miles. If you are a little farther out—by only a few miles—you will miss the Earth, and go around and come back again, unable to enter at the correct angle. If you are in a little too close, you will burn up.

It is a very troublesome technical problem. We have given this estimate: we think we will be able to send unmanned vehicles to the Moon and back and solve that particular problem, perhaps before the end of this decade.

The problems connected with manned flight to the Moon, and return, we think go slightly beyond the period for which we have projected the program. I don't think it is many years beyond.

Mr. ROUSH. I would just like to close, Mr. Chairman, with a rather simple personal observation. I wish that either AEC would provide a reactor or an engine and tell someone to build a vehicle for it, or

someone would build a vehicle and tell them to build an engine that would fit it.

Dr. DRYDEN. They have to go together, unfortunately. You must build them simultaneously so they meet and fit. The AEC's job is the reactor part of it. The rest of the engine is in NASA and the vehicle is in NASA. We have outlined a program which, so far as I know, in the opinion of the technical people working on it is moving just as rapidly as the technology will let it go.

Mr. ROUSH. I am sorry you haven't dispelled the impression I had that you are waiting for each other to act. I still have that. That is all, Mr. Chairman.

Mr. SISK. The gentleman from California.

Mr. MCDONOUGH. Is the development of both the vehicle and the engine as you go forward to the point of meeting the two agencies' specifications all creative work? Is this all new creative work?

Dr. DRYDEN. Yes, it is all new work. I have explained how our part——

Mr. MCDONOUGH. Is it definitely a research and development program on which there is no precedence?

Dr. DRYDEN. Mr. Finger mentioned that our development of the pump which is a necessary part of this engine, has gone much better than anticipated as a result of which the original timetable of some of the work on the reactor engine combination can be moved forward.

The time scale is reduced because that particular development has gone unusually well. So we are developing the pieces of the engine which come together as an engine for the first time in this breadboard demonstration engine, showing the feasibility of the whole thing.

The rocket nozzle is the other principal part. The tanks are something which can come along when the vehicle is developed.

Mr. MCDONOUGH. In considering the budget before us now, is this nuclear development for the next fiscal year, 1961, provided for in this $4,300,000?

Dr. DRYDEN. No, sir. The AEC has the budget for the development. It is many times this number.

Mr. MCDONOUGH. That is right. We are not considering here today the amount of money they are going to spend to develop this nuclear engine?

Dr. DRYDEN. No, sir.

Mr. MCDONOUGH. The amount of money that is provided here for support for reactor test Rover is $4,300,000. You described it, Mr. Finger. Will you again review it just for my information?

Mr. FINGER. There are four principal items in that $4.3 million. One is the pump, extension of the operating capabilities of the pump beyond what is now possible, and beyond what is now essential to the reactor test program.

The second is development of a turbine to drive this pump. This will be used in the breadboard engine. It may not be used at any time in the reactor program before we get to the breadboard engine, so this is a long leadtime development, and it is a new state of art development.

The third item is the liquid hydrogen cooled nozzle, which again is beyond our present know-how. We will be developing new techniques and it will involve new methods of testing. At this point we have

the question of whether or not we can even mock up the heat load on this nozzle by any other means than by using a hydrogen gas that has been heated in a reactor.

So it is very possible that this nozzle will be put on the reactor test without having been tested at the conditions to which it will be subjected in the reactor test.

Mr. McDonough. And the fourth item?

Mr. Finger. The fourth item is the supply of all hydrogen propellant to the reactor program.

Mr. McDonough. Well, now, is the $4,300,000 intended for that purpose sufficient to accomplish what you have programed for 1961?

Mr. Finger. Yes, sir; it is.

Mr. McDonough. Now, on the applied research on nuclear rockets, you have a million dollars for this year.

Mr. Finger. Yes.

Mr. McDonough. That is $100,000 less than last year.

Is that sufficient for your program for this year?

Mr. Finger. Yes; it is. The main reason for the decrease is that at that point we will be in the phase of operating a test loop which has been designed and built to test the radiation effects at low temperature.

The higher moneys in 1959 and 1960 were the result of the phase of the program where we were designing and building the hardware. In 1961 it becomes a matter of using the hardware, and this is a lower cost process.

Mr. McDonough. And, of course, the breadboard engine design, is that——

Mr. Finger. That is really the start of the flight system design.

Mr. McDonough. That is only on the board; this amount of money is for boardwork?

Mr. Finger. For design study work, not hardware work.

Mr. McDonough. Not physical testing work?

Mr. Finger. That is correct.

Mr. McDonough. I see. So that is a total of $5,500,000, and in your judgment—both you and Dr. Dryden—do you think that that is sufficient to carry out what you have planned and to meet the urgent demands of this committee that we move as fast as possible?

Mr. Finger. Yes; I believe it is at this time.

Dr. Dryden. Plus the amount in the AEC budget. Do you remember the number offhand?

Mr. Finger. Approximately $20 million in operations, and $20 million authorization requested for facilities.

Mr. McDonough. The persistent demands on the part of the committee that we move faster is, of course, a reflection of public opinion, through Members of Congress?

Mr. Finger. Yes.

Mr. McDonough. As you readily realize, we find ourselves exposed to two bodies of opinion. One, some of the public says, "Well, it won't do us any good to shoot the moon; let's use the money for increase in social security," or something of that sort. On the other hand, we say, "Why are we standing around as a second-rate nation?

I think that in view of the present trends toward international influence, the position the United States has taken, and the influence

that we must maintain with our allies as a defense potential, we have got to be assured that we are moving in space research and development with ultimate speed, and that we have the capability of doing as much as possible in the shortest period of time.

I am wondering if there is any proposal from industry that has stimulated action here? Is industry bringing proposals to you that might speed up this kind of a job?

Mr. FINGER. Industry proposes to us frequently on these nonnuclear components which we support. Our work covered by this item is all industry contract work. No inhouse work is covered in this item. There is in addition an inhouse research program going on that will supply information for this program.

The AEC reactor work is conducted at Los Alamos. As time goes by, it is quite clear that a great deal of their work will have to be contracted out. For example, building fuel elements becomes a chore that requires manpower and large facilities. That type of work may best be done outside, generally. This is recognized, I am sure.

Dr. DRYDEN. Mr. McDonough, I wonder if this statement would be helpful: I think all of us feel very deeply this sense of urgency, and we regret that metal and materials are so intractable that one cannot easily fashion them into shape. With all the money in the world, with access to all the manpower in the world, it took 5 years to develop an Atlas missile which is far less complicated than the device we are talking about here.

We don't like that; we don't like to accept that fact, but it seems to be a fact of nature.

Off the record.

(Discussion off the record.)

Dr. DRYDEN. It is a fact that we can't, by drawing lines on a piece of paper, get this material into shape and get it tested and tried and repair the failures. Even to build a house from the time the architect conceives it and puts it on a piece of paper takes some time, and it is a little bit difficult with money alone to move this very much faster.

Mr. MCDONOUGH. Dr. Dryden, I appreciate your opinion, because you have been through the history of aviation probably as thoroughly as any man in the United States. You have been through the development of the new type of air transportation.

In your opinion, do you think we are moving as fast in this new field as we did move in aviation?

Dr. DRYDEN. We are moving a whole lot faster.

Mr. MCDONOUGH. A whole lot faster?

Dr. DRYDEN. Very much faster. This is because of greater public interest and public support. In contrast, the airplane in the early days got no support at all; in fact, it went abroad to be developed.

Mr. MCDONOUGH. But even since the airplane in the more modern era, for instance, the last 15 to 20 years, it has moved pretty fast.

Dr. DRYDEN. It has been going at a very rapid rate.

Mr. MCDONOUGH. That is right, you have been in the middle of it. You think we are moving equally as fast in this new means of transportation which is far more complicated?

Dr. DRYDEN. I think we are moving faster.

Mr. MCDONOUGH. All right.

Mr. SISK. The gentleman from New Mexico.

Mr. MORRIS. I would like to ask what are the reentry problems which you face?

Dr. DRYDEN. You mean so far as the general subject is concerned?

Mr. MORRIS. Yes, sir.

Dr. DRYDEN. The reentry problem has been solved, of course, for ballistic missiles which travel at suborbital speeds. We fish them out of the ocean, we have taken a look at them. We know this works.

Mr. MORRIS. I see.

Dr. DRYDEN. There are attempts being made to recover packages from satellite speeds. So far they have been unsuccessful for various reasons. I think it is only a matter of relatively short time before those experiments will be successful.

In Project Mercury we are attempting to bring back a package of the weight of approximately 1 ton, containing a man, and the developmental tests we have made so far have shown that the same methods used in the ballistic missile, with a little greater thickness of material—and therefore a little bit more weight—are sufficient to deal with the small increase in speed from the ballistic missile to the satellite vehicle.

When we go to the moon and come back, we step up the speed and the energy again. I think there is the greatest confidence on the part of people that the same ablation methods can be engineered to work.

If they cannot be made to work, there are the techniques of using porous surfaces and ejecting materials which certainly can be made to work.

I think so far as the heat protection is concerned, the prospects are extremely good indeed, although you still have to prove all these things.

The other reentry problem is one of guidance. Now, in the case of the present recovery experiments, I think you are familiar with some of the problems of getting the airplanes and ships stationed in the right place. As I mentioned, so far these attempts to recover packages from satellite speeds have not been successful, but I think they will be in a relatively short time.

In Project Mercury we cannot control the exact place where the capsule comes down, but we will, by observation and computers, be able to predict it pretty well before the object lands.

The reentry of the Mercury capsule from a height of 120 miles does not present any unusual guidance problem.

As I mentioned, the problem is different when we go out to the Moon and attempt to come back to the Earth. With the accompanying very high speed, we have two engineering choices. One, which requires a very much heavier vehicle, is to try to rely on retrorockets to reduce the speed, so that we get down into the speed range where we do have knowledge. The other is to do a better guidance job.

The analyses show that with a drag vehicle, the guidance requirements are almost impossible to meet.

However, with the so-called lifting-type of vehicle that you have heard about before, the tolerance becomes much greater, and it does seem to be possible with guidance systems of the type that we know to reenter the atmosphere safely.

With a drag vehicle you have to hit a given spot a few hundred miles above the Earth's surface with an accuracy of plus or minus 3

miles. With a lifting vehicle, this widens out. I don't recall the numbers, but it is 10 times or more, perhaps plus or minus 50 miles, which begins to get down within reason.

Now, in much later phases, if you go out to Mars or to some other planet and come back, the problem is still more difficult.

What I am trying to say is this: as the speed goes up, you have the heat protection problem which has been solved up to a certain point and looks quite possible. The guidance problems are getting more difficult. This is a brief sketch of the so-called reentry problem.

One other point I forgot; a lifting vehicle is also of interest from the point of view of controlling the point of landing to within certain limits. This cannot be done with the drag-type vehicle alone. This is a very hurried rundown of the situation.

Mr. MORRIS. Well, would a large solar furnace be of assistance to research in this field?

Dr. DRYDEN. Large solar furnaces are used primarily for materials—high-temperature materials investigation.

Mr. MORRIS. Isn't that one of the problems that you have?

Dr. DRYDEN. It is not possible to study ablation cooling without having the very high speed of the air past the surface, so you cannot use a solar furnace to study the ablation cooling problem, or any of these cooling problems of vehicles moving at high speeds.

Mr. MORRIS. You mean to say that you don't have any problems with the metal?

Dr. DRYDEN. No, I didn't say that. I said the particular problem of reentry you're are speaking of cannot be investigated in a solar furnace. The solar furnace is very good for some of the problems of materials—of rocket nozzles, for example, some of the ceramic liners for rocket nozzles.

There is a field of application of solar furnaces in high-temperature metallurgy, but generally not where you are talking about the cooling problem at very high speeds.

Mr. MORRIS. I believe one the problems that you listed, the fourth one that you had, was concerned with nozzles?

Dr. DRYDEN. That is correct, nozzles.

Mr. MORRIS. A large solar furnace would not be of any assistance in researching this problem.

Dr. DRYDEN. It is, except that with a project like Rover, we are talking about temperatures which are beyond the capacity of any material we know. We are talking about 4,000° or 5,000°. Is this correct?

Mr. FINGER. Yes.

Dr. DRYDEN. You have to cool it, in other words. You can't make a material that won't melt at these temperatures.

Mr. MORRIS. That is any material you know of at the present time.

Dr. DRYDEN. This is correct. There are people who think they understand solid-state physics, who say there are certain limits to what any solid made up out of electrons, protons, and neutrons that we know about, could withstand. I don't know whether they are right or not.

Mr. MORRIS. Well, I don't know either, but I wanted to know what your answer would be.

Dr. DRYDEN. The solar furnace is a tool for basic research on materials which is of very great use, not only for space programs, but also for aeronautical and missile programs.

Mr. MORRIS. Thank you.

It seems to me that, in all of our hearings, there is something missing somewhere, and I don't know where it is. Mr. Roush went into the question of the engine and the vehicle. It seems to be the opinion of everyone concerned that we are all interested in the subject, we all want it to go forward as fast as possible, and as fast as it is economically feasible. But is there, to your knowledge, any basic research area, where we are not doing enough work in basic research?

Dr. DRYDEN. I think it is the general opinion of scientific people that the really basic research—which is not quite the applied research on materials you are talking about, but the attempt to understand how to create a new material, with new properties, the attempt to understand nature—that kind of research is not supported enough.

One reason, of course, is you don't know whether any specific piece of that research will produce any results or not. It is a gamble. You may work for several years, spend a lot of money, and have no result of use and practice come out.

On the other hand, the importance of basic research has been proved time and time again. I guess the most recent popular booklet on this subject was one Arthur D. Little worked up for the Navy, giving examples of what basic research has done. They gave one illustration of interest in the space field—a history of shock wave research going back into the 1880's when the first mathematicians developed theories, then tracing progress all the way down to the present time, through the work of Kantrowitz, and others, on these problems.

Basic research considered as a whole, pays dividends, usually some years in the future. And most scientists think there is not sufficient support of that particular type of research.

Such long range basic research is not likely to help us catch up with the Russians in the next 10 years.

Mr. MORRIS. Thank you.

Dr. DRYDEN. It will help us in the long-range competition.

Mr. SISK. There certainly isn't any doubt that we need to devote a lot of efforts to real basic research. But, as you say, that is something that pays off 20 years or 50 years in the future.

Dr. DRYDEN. That is right.

Mr. SISK. Mr. Hines, do you have questions?

Mr. HINES. Yes, sir.

Mr. Finger, we heard some very exciting dates this morning and some very positive statements by General Branch and his associate.

Do you think that these dates are realistic?

Mr. FINGER. As I recall, General Branch, in answer to a question, said that he thought a propulsion system could be available in the midsixties. And I think that is correct.

Mr. HINES. Would it be a practical, usable system? One that NASA might want to use?

Dr. DRYDEN. A flight test system.

Mr. FINGER. Yes, a system that could be used to effectively flight test nuclear rockets.

It might not be as light as we would like or have the power we would like, but it would be a propulsion system. If a large enough gross weight vehicle could be built around it, yes, it could do useful missions.

Mr. HINES. Has NASA undertaken any investigations of the possible use of these vehicles in its space programs?

Mr. FINGER. Oh, yes. I have done an analysis of my own. We have had people inhouse doing such work. We also had people in industry doing a great deal of this type of work.

Dr. DRYDEN. You mentioned the result on the lunar mission.

Mr. FINGER. The lunar mission we mentioned earlier is an example. The Los Alamos data has been fed into these analyses, and they are still continuing. We are not done by any means.

There is a word of caution here. We can go through and calculate the payloads that we can anticipate, using the reactors being developed. They involve assumptions of controllability, materials development, and so on, but in addition they involve at this point assumptions about what vehicles we will put these nuclear stages onto.

In other words, we can make calculations that tell us we can go out to Mars, orbit Mars and return, and everything looks fine, but we may have a vehicle that has the fineness ratio of three pencils standing end-to-end one on top of the other. It may not be a practical vehicle.

Until we get more detail on the engine system and the space environment, we really can't determine definitely how practical we can make this system look.

Mr. HINES. This is the conclusion of your analysis?

Mr. FINGER. Yes.

Mr. HINES. As of this moment?

Mr. FINGER. Yes. From a theoretical payload point of view these rockets look very promising. That is why we consider them as one of our major advanced technology items.

Mr. HINES. Do you foresee a possible engineering breakthrough?

Mr. FINGER. No, I believe this requires just hard, steady work. These are not going to be breakthroughs. These are going to be research and development results.

We are working with materials of which we know the limitations. It is a matter of designing to get around these limitations.

This pump was no breakthrough. It was a development, a logical development, and its performance was more gratifying than we anticipated it might be so soon after we initiated development.

This may happen with other components. It may also go the other way. Some of the components may not work out quite as well as we would hope.

Mr. HINES. Thank you.

Mr. SISK. Mr. Wilcove?

Mr. WILCOVE. Dr. Dryden, NASA has announced a 10-year program for this decade.

Do you think this program will enable the United States to come abreast of the Soviet Union in the space race?

Dr. DRYDEN. Yes, I do, I think it is a much broader base program than the Russian program as we have seen it. I think this is really the only way to compete with the Russians.

Mr. WILCOVE. Dr. Glennan, I believe, testified his estimation is that Russia is about 5 years ahead of us.

Dr. DRYDEN. I think he testified that the best guess was it would take about 5 years to catch up.

Mr. WILCOVE. Five years to catch up?

Dr. DRYDEN. The difference—I hope you don't think I am straining at a fine point—the difference is, we talk about a few years, less than 5 years' difference now, but it is going to take us this period to get to a certain stage and the Russians aren't going to stand still in the meantime.

Mr. WILCOVE. That leaves the assumption that the Russians, who are far ahead of us now, will not be moving as fast as we will be moving?

Dr. DRYDEN. Yes. May I say "catch up" in this sense refers solely to one thing, which is weight in orbit, or thrust of boosters. We may beat the Russians by quite a bit in the meteorological satellite or in some of the many other various phases of our program.

I will say it again; it is like the Olympics competition. There are a large number of events in this business. We think that our program is broadly enough based so that it will get ahead of the Russians.

I don't recall whether I have said this to this committee before or not. The reason we sort of stand off at the word "race" is this: A race implies a starting line, a starter with a pistol, a goal line where everybody knows where it is, both parties start at the same moment, run toward that goal line, and the winner is the fellow who gets there first.

With the present Russian space program, we don't know where the goal line is, because we don't know what they are putting their effort on primarily. They are probably halfway down the road before we know what particular race they have decided to run this moment, and it is a pretty unintelligent person who tries to run a race when he discovers that the opponent is halfway toward the goal line before he starts. This is the reason we call it a competition, a broad-base competition with many events. We have tried to get our lines underway so that we are going to come in first in a great many events, and that we will come to a position of leadership in the area of space technology and its uses for mankind.

Mr. WILCOVE. Doctor, regardless of whether you call it a race or competition, the Russians go in for spectacular events. We all know that. They captured the imagination of the world with some of their feats.

I think, without looking into the future too much, we may go on the assumption that one of the spectacular feats the Russians are thinking of is getting a manned expedition to the Moon.

I think we could assume that is one of the goals that the Russians are aiming at.

Dr. DRYDEN. It is one of our goals.

Mr. WILCOVE. I am talking about the Russian goal though. I think we can say there is a goal we know of that the Russians are aiming at.

Dr. DRYDEN. We do not know this as a fact.

Mr. WILCOVE. No, I appreciate that.

Dr. DRYDEN. The Russians haven't put up a satellite recently. We don't know why. Why they don't go into meteorological communica-

tions satellites, we just don't know. Whether they will put man in space, whether they will go to the Moon or Mars next fall, we haven't the slightest idea. We know one thing, they will not do all of them. They just will not do all those things simultaneously.

Mr. WILCOVE. Well, I think we must go on the assumption, Doctor, that they will try a spectacular feat like that to land a manned expedition on the Moon. I don't think it is safe for us to assume they may not.

Dr. DRYDEN. I am not assuming they may not.

Mr. WILCOVE. All right. Let's assume that as a definite goal of the Russians.

There is no question in my mind but what they are looking ahead to the time when they will land a manned expedition on the Moon.

Some Russians have set the date as 1967, which is the 50th anniversary of the Russian Revolution.

Dr. DRYDEN. What Russians? This is the problem.

Mr. WILCOVE. You will have to ask General Medaris that. I don't think he specified which Russians.

Dr. DRYDEN. My experience with Russians is the same as with Americans. There are science-fiction writers, there are scientists, there are political people in government and they make very different kinds of statements. You will not find the Russian scientist engaged in the space program making that kind of a statement.

Mr. WILCOVE. As I say, I think it isn't safe for this country to go on any other assumption.

Assume we go on that assumption, that the Russians are aiming at landing a manned expedition on the Moon.

I think we can assume they are considerably ahead of us now in this project because they have larger booster capacity, for one thing.

Just because they are way down the road, and they may reach the goal before us, do you think then that we should not get into the race or competition?

Dr. DRYDEN. Not at all. I have tried to say we are developing a technology across a broad front which, in time, will let us do anything we want to do—anything we want to do.

Mr. WILCOVE. The time element is what I am worried about.

If I may use this analogy, and I think it has been used before: If we are moving at the same speed that the Russians are moving, they are down the road going 60 miles an hour in a car——

Dr. DRYDEN. This has no meaning expressed broadly. The universe and the things you can do in space are so varied and so broad, unless you limit this to one statement, namely, that they have one goal which is man on the Moon, and this is the only thing they are working on, this statement has no meaning. If you say they are running 60 miles an hour toward the Moon, then your analogy becomes something. But to say this broadly in the whole universe of space, it has no specific meaning.

Mr. WILCOVE. I am afraid, regardless of what else the United States achieves in space, if Russia beats us to the Moon it won't comfort us too much, no matter what else we achieve, in the minds of people in this country and in the minds of world opinion.

Dr. DRYDEN. I am afraid we disagree somewhat on taking one specific thing. Why don't you say beat us to Mars or to Venus, or man

in space, or meteorological satellite for weather observations for the benefit of all mankind?

Mr. WILCOVE. All right, let's take a man in space. There are all kinds of predictions.

Dr. DRYDEN. We have a sporting chance in beating them on that, in my opinion.

Mr. WILCOVE. You feel we do?

Dr. DRYDEN. Yes—a sporting chance.

Mr. WILCOVE. I mentioned the Moon instead of Mars and Venus because it is considerably closer.

Dr. DRYDEN. The technical problems are the same order of magnitude.

The most difficult mission of all is a 24-hour satellite, more difficult than the Moon mission.

Mr. WILCOVE. Do you feel, Doctor, this country has a good chance to get to the Moon with a manned expedition before the Russians?

Dr. DRYDEN. This depends on what the Russians decide to do, whether they pick that goal or some other one. I just don't know how to answer it with the absence of knowledge of what they have selected as the place to put their principal effort.

I think that, generally speaking, in almost any competitive effort that you can think of, that even in military wars the focusing of effort on one point may give a temporary advantage in a limited area. There is not very much the defense can do about that.

Mr. WILCOVE. To use your analogy, let us say the Russians are headed for the Moon at 60 miles an hour. We know their goal. Let's assume that. Do you think we could beat them to the Moon?

Dr. DRYDEN. This again, I think there would be a sporting chance, but I don't know how to answer this positively.

We can't even make a decent try until some of these developments, that I have said take a certain amount of time, are finished.

Mr. WILCOVE. Of course, the Russians face the same obstacles.

Dr. DRYDEN. We started this, you recall. When ARPA was first established we made an attempt at the Moon with devices every scientist knew had very small chance of success, but we hoped that the dice would fall our way. They didn't.

Now we are going to make some more tries at the Moon, as you know. Still the chances are not such that you can bet 100 percent on the results. We are going to keep trying, and we are going to develop the technology so we can do anything we want to do in space.

Mr. SISK. We are very happy to have Dr. Sheldon with us today. Dr. Sheldon, do you have any comments or questions?

Dr. SHELDON. No comments, thank you.

Mr. SISK. We are happy you sat in with us today.

Just a few concluding questions, Dr. Dryden.

I believe, Mr. Finger, you were here this morning when we had a very brief discussion of Project Orion. The reason for our having that testimony was based on the fact that there had been hopes that NASA might assume responsibility for that project.

Project Orion is apparently a long-range project, and probably there is a lot of basic research involved in it. It is at a very preliminary stage, but its ultimate aim or objective, it seems to me, would be something that NASA might be interested in.

I wondered, Dr. Dryden, if you have any comments on why NASA chose not to accept responsibility for that program at the present time?

Dr. DRYDEN. It is primarily a tremendous engineering proposition, with very great engineering difficulties. It cannot be tried on any small scale. It looks like it costs a billion dollars just to try the idea to see whether it works.

It involves nuclear explosions—a very large number of them—in the atmosphere, which presents some international and political problems at the present time. That type of experimentation is not permitted at the present moment.

I think we are interested in it as a general research proposition. We have been following it with interest. The Defense Department has been interested in it.

Mr. SISK. I understand that a fairly small amount of money somewhere in the neighborhood of a million dollars a year has been requested for Project Orion in the hopes of at least continuing the basic research, and that possibly there was some possibility that either it might be dropped, or that progress would not go forward unless maybe NASA or some other agency takes it over. At least I have been led to believe that. That is why I did have some concern. I appreciate the long-range aspects of this nuclear explosion proposition, I am not being critical of it due to the international basis.

Dr. DRYDEN. I would say we don't have very many millions of dollars to put out, but if it were a million dollars and going to continue very long at this I think the answer would be quite different. But it is quite obvious to us the cost of this thing is going to go up very rapidly if any real progress is to be made.

I have explained you can't do anything on a model. Apparently, unless you spend a very large sum, indeed, you can't even tell whether the project will work.

Theoretically, there are many eminent physicists who have looked at it. They have found no fundamental scientific problem. There is a vast engineering problem.

I have expressed the view to the people on the project that maybe it is like the case of the first big iron ship across the Atlantic. There was nothing wrong with it in theory, it was just a little bit ahead of its time.

Mr. SISK. I appreciate that. Of course, I think that is what some of us may be seeking. Maybe we are expecting too much of you scientists; we are expecting something big. I am sure you share that desire along with all of us who, as laymen, frankly don't understand many of the engineering and technical details involved.

The only question, as I say, in bringing it up, is that there are apparently quite a few people that do feel that it does have promise as a long-range program, and I would hope——

Dr. DRYDEN. I would agree.

Mr. Sisk——that if there is promise it not be dropped by the wayside, merely because of budgetary considerations.

Now, of course, it is up to Congress. If NASA chose to assume the responsibility for Project Orion, of course it would be up to the Congress whether or not we made available to you the funds to carry it on. The only point that we had in bringing it up was the idea that if there was sufficient justification for Congress to invest at least a mil-

lion dollars to look a little further into it this year, that this committee might consider the possibility, assuming NASA took it over, of making such moneys available. That is merely my own personal opinion; don't misunderstand me. I am not necessarily reflecting the feelings of the committee as a whole. But I thought it was something I should bring up. That is why I was interested.

Dr. DRYDEN. I think, Mr. Sisk, this does bring up one point in which really the advice of the committee would be most valuable.

You have hear Mr. Wilcove's expression about a particular project. Should the Nation's space program be based on selecting a narrow line like this and driving down that alone? Should we take projects like Orion, where the gamble is very great indeed, and the psychological consequences of a failure on it are very large?

Now, of course, this particular one, Orion, is pretty far away. We have taken the view, as you know, on the Moon proposition that we keep trying with what we have, perhaps not putting an unduly large effort when the risks are high and chances of success not too great. Some people said we would be better not to try it at all; it would be better not to try at all rather than to try and fail.

We have gone on the premise that we should try with what we have at hand, but work like everything to get better tools, more accurate tools to do the job.

We have not felt it advisable to draw an extremely narrow program of spectaculars. We believe that space is going to be here a long time. There is an awful lot of room out there. We must have a very broad program. We have got to explore the possibilities of economic use and application; certainly the military has to explore military applications. We think that the best policy for the United States is a broad-base program to move forward just as rapidly as we can.

If the committee thinks otherwise, I think this kind of an expression would be useful to have. I can't promise, of course, that it would be followed, but at least we would know what the opinion of the committee is.

Mr. SISK. I appreciate that expression, Dr. Dryden, very much, and I agree with you that we should share with you to some extent the responsibilities. The Congress, of course, holds the purse strings and certain policymaking powers. This committee, of course, having jurisdiction, wants to work closely with you and do everything that we can to assist you.

I understand, of course, that your philosophy is to move forward on the broad field, and to bring the whole front along pretty well together.

There are some of us—and I for one will plead guilty— that have been somewhat concerned, frankly, with the real strong desire to do something that might be considered, let's say, almost a spectacular stunt. Frankly I will admit that I have a rather strong feeling—and I know it is shared in by others—that our world prestige of late has suffered to some extent. Of course, I am looking ahead. If, for example, there were two or three spectacular accomplishments in space technology achieved by another power in, let's say, the next 5 or 10 years, that we were unable to duplicate or come anywhere close to, I frankly would have some real deep concern. I am sure you share that, Dr. Dryden.

Dr. DRYDEN. We share that.

Mr. SISK. That is why, as you probably know, I questioned Mr. Horner and his colleagues rather extensively on the F–1 engine, and whether or not we were doing everything that we should be doing with the idea in mind that the Nova configuration might be the vehicle that could give us a great step forward, you see?

I will conclude with one question:

Do you agree fully that we are doing probably everything on the F–1 engine that we should or could do at the present time?

Dr. DRYDEN. We are doing, I think, all that we can at the moment; yes, sir.

Now, may I say on this other matter, that we have had this same desire for spectaculars. I don't think those of us who are scientists or in NASA are any different than people on the outside in this regard.

Our problem is, when you begin to ask specific suggestions, everybody wants to go in a different direction. If Congress has anything to say on that, we certainly would like to hear it.

When NASA was organized, we went into such a program—which, as you know, did not succeed—a mission to the planets. This was undertaken just with that feeling in mind at the time that we needed something like that, that we ought to try. We didn't feel we had quite the technology that would guarantee that we would do it. Nevertheless, we went ahead. When it became apparent to everybody concerned that the mission chances were very small, we made a change in the purposes of the mission, as you know.

Mr. SISK. I said that was the last. I do see I have noted one other thing:

This refers back to a statement made by General Branch this morning, and I am not placing it strictly on the point of prestige or psychological effect either. Do you agree that, basically, it would be a fine objective if we could proceed ahead as rapidly as we could on this development of nuclear propulsion? In view of what I believe to be the state of the nuclear art in this country which is substantially ahead of anyone else in the world, that we could fly the first satellite with nuclear propulsion?

Dr. DRYDEN. This certainly would be a prestige item. It certainly qualifies as such.

Mr. SISK. Not only a prestige item but it could have real practical effects.

I would hope you are moving along that line. I think this committe would share with you in that feeling.

Are there any other questions before we conclude?

Unless there are, gentlemen, I want to say that we deeply appreciate your coming down, Dr. Dryden, and you, Mr. Finger, and for assisting us in the consideration of this nuclear budget section.

We have gone over and have taken final action on all portions of the budget except this item of $10 million, and the liquid rocket item of, I believe, $63 million. We hope to conclude this afternoon on that.

Now, while you gentlemen are still here, do you anticipate the possibility of needing supplemental money in any of these programs, let's say, during the coming year?

I realize that this is conjecture as yet. But, do you feel that there are possibilities of breakthroughs here and there where additional funds in certain fields could be substantially beneficial? Do you feel there is any chance of that, or do you think that——

Dr. DRYDEN. I think the only answer I could give is one that both Dr. Glennan and myself gave last year. If we need money, we will be back, and we have been back, the first two years in succession for various reasons. We have asked for the money we think we need, and as has been covered by testimony, we got pretty much what we asked for.

There will be conditions which arise, both of the kind that you mention, and possibly also still, in spite of another year's experience, of a failure to estimate costs accurately.

If we need it, we will be back.

Mr. SISK. We hope that you have some breakthroughs so promising that you will be back, not because we want to spend the taxpayer's money, you understand, but because the achievement will be so great, and the possibilities look so good, that with a little more money, we might attain that goal we are talking about.

Thank you a lot, gentlemen.

Mr. FINGER. Thank you.

Mr. SISK. I think Mr. Wilcove has thought of one further thing.

Mr. WILCOVE. I have one more question, Doctor, in line with the questioning of the chairman.

In a trade magazine it was stated that NASA is now preparing a program in which more money will be asked for the 1961 fiscal year.

I assume from what you already said that the answer is "No"?

Dr .DRYDEN. The answer is "No."

Mr. WILCOVE. Thank you.

Mr. SISK. Thank you a lot, gentlemen.

The Committee will now go into excutive session.

(Whereupon, at 3 :36 p.m., the subcommittee proceeded in executive session.)

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